UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

STAT [redacted]

ODP #1955-76

1976 September 30

MEMORANDUM FOR FIPS Points of Contact

From: Harry S. White, Jr.
Associate Director for ADP Standards

Subject: Coordination of Three Proposed Standards for Magnetic Media

Enclosed, for your consideration are three proposed Federal Information Processing Standards (FIPS) for Magnetic Tape Cassettes, Tape Cartridges, and Magnetic Tape (6250 CPI, Group Coded Recording). These three proposed FIPS are the Federal adoption of voluntary industry standards developed under the auspices of the American National Standards Institute. (These proposals were provided to you earlier, but had to be ignored due to problems in the reproduction process. Reference my memoranda of September 15 and September 22, subject as above.)

In order to ensure that all agencies have an opportunity to present their views, NBS is soliciting your comments on these proposals. If you find that your agency cannot concur with these proposed standards, please indicate specific changes that you feel are needed.

Also, please indicate to what extent these proposed standards are applicable to your agency and the expected impact these will have on increasing the efficiency and economy of your ADP systems operations.

Please submit your comments within ninety days of the date of this memorandum to: Associate Director for ADP Standards
Institute for Computer Sciences and Technology
National Bureau of Standards
Washington, D.C. 20234

Concurrences will be assumed if a response is not received by this date.

Enclosures

cc: State Information Systems Coordinators

Announcing the Standard for RECORDED MAGNETIC TAPE CARTRIDGE FOR INFORMATION INTERCHANGE, 4-TRACK, 6.30 mm (0.250 in), 63 bpmm (1600 bpi), PHASE ENCODED

Federal Information Processing Standards Publications are issued by the National Bureau of Standards pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), Executive Order 11717 (38 FR 12315), dated May 11, 1973), and Part 6 of Title 15 CFR (Code of Federal Regulations).

Name of Standard. Recorded Magnetic Tape Cartridge for Information Interchange, 4-Track, 6.30 mm (0.250 in), 63 bpmm (1600 bpi), Phase Encoded (FIPS PUB __).

Category of Standard. Hardware Standard, Interchange Codes and Media.

Explanation. This standard specifies the recorded characteristics for a 6.30 mm (0.250 in) wide magnetic tape cartridge with either one, two, or four serial data tracks in order to provide for data interchange between information processing systems, communication systems, and associated equipment at a recording density of 63 bits per millimeter (1600 bits per inch) using phase encoding techniques. This standard is one of a series of Federal Standards implementing the Federal Standard Code for Information Interchange (FIPS 1) on magnetic tape media.

Approving Authority. Secretary of Commerce.

Maintenance Agency. Department of Commerce, National Bureau of Standards (Institute for Computer Sciences and Technology).

Cross Index.

a. American National Standard X3.56-1976, Recorded Magnetic Tape Cartridge for Information Interchange, 4-Track, 0.250 in (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded.

b. American National Standard X3.55-1976, Unrecorded Magnetic Tape Cartridge for Information Interchange.

c. FIPS PUB 1, Federal Standard Code for Information Interchange.

d. FIPS PUB 35, Code Extension Techniques in 7 or 8 Bits.

e. At the time of publication of this FIPS PUB, a standard for parallel, 4-track, recording for a 6.30 mm (0.250 in) magnetic tape cartridge was under development by the American National Standards Institute. This voluntary industry standard, when available, will be considered for Federal adoption as a FIPS.

Applicability. This standard is applicable to the acquisition and use to all magnetic tape cartridge recording and reproducing equipments employing 6.30 millimeter (0.250 inch) wide magnetic tape with one, two, or four independent serial data tracks at recording densities of 63 bits per millimeter (1600 bits per inch) using phase encoding. Federal information processing systems employing such equipment, including associated software, shall provide the capability to accept and generate recorded magnetic tape cartridges in compliance with the requirements set forth in this standard.

Specifications. With one exception, this standard adopts the specifications set forth in American National Standard X3.56-1976, Recorded Magnetic Tape Cartridge for Information Interchange, 4-Track, 0.250 in (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded. This exception changes the last sentence of paragraph 4.3.1 to read: "The eighth position shall be a zero when recording ASCII (FIPS 1) characters and can be other than zero when recording dense numeric, binary or extended (FIPS 35) code representations.

Implementation Schedule. All applicable equipment ordered on or after the date of this FIPS PUB must be in conformance with this standard unless a waiver has been obtained in accordance with the procedure described below.

Federal departments and agencies are responsible for issuing specific internal implementation instructions for the use by this standard by their organizational units and for assuring that copies of this FIPS PUB and its associated technical specification (American National Standard X3.56-1976) are made available to all effected parties.

Special Information. Federal standards and/or specifications for unrecorded magnetic tape cartridges will be developed and issued by the General Services Administration. Until such time as these are available, American National Standard X3.55-1976, Unrecorded Magnetic Tape Cartridge for Information Interchange, should be cited in Federal procurements.

Also GSA will provide terminology for use of this standard in Federal ADP acquisitions. This terminology will be incorporated in the Federal Property Management Regulations (Title 41, Subtitle C, Part 101, Subpart 101-32.13, Code of Federal Regulations).

Qualifications. None.

Waiver Procedures. (The approval and processing of waivers to Federal Information Processing Standards is currently being reviewed by the Department of Commerce and will be provided in the printed version of this FIPS PUB.)

Where to Obtain Copies of the Specifications.

(To be completed by NBS.)

BSR X3.56

X3B5/75-44
1975 April 16
Rev of X3B5/75-19
Editorially revised
1976 April 14
1976 June 9

Fifth Draft
Proposed

American National Standard

RECORDED MAGNETIC TAPE CARTRIDGE FOR INFORMATION INTERCHANGE

4 TRACK, 0.250 Inch (6.30mm), 1600 BPI (63bpmm), Phase Encoded

This draft standard is published for a four-month period of public review and comment. Comments received during this period will be considered and answered. The draft standard, revised as necessary, will then be submitted to American National Standards Committee X3 for letter ballot. Upon completion of the ballot, the proposal will be forwarded to the American National Standards Institute for approval as an American National Standard.

Comments should be returned as soon as possible but not later than 1975 November 19, addressed to:

CBEMA/Secretary X3
1828 "L" St NW
Washington DC 20036

Prepared by

Technical Committee X3B5 - Magnetic Tape Cassettes

American National Standards Committee
X3 - Computers and Information Processing

Secretariat: Computer and Business Equipment Manufacturers Association

FOREWORD

(This Foreword is not part of the American National Standard Recorded Magnetic Tape Cartridge for Information Interchange, 1600 bpi (63 bpmm) Phase Encoded, X3.XX-19XX).

This AN Standard presents the standard technique for recording the USA Standard Code for Information Interchange X3.4-1968 (ASCII) and amendments thereto on a magnetic tape cartridge at 1600 bpi (63bpmm) using phase recording techniques. It is one of a series of standards implementing the ASCII in media.

Related standards define more fully the physical and magnetic properties of the magnetic tape cartridge and specify a standard record format and labels.

The X3B5 Technical Committee which developed this document consists of a group of experienced and qualified specialists on recording of digital information on magnetic tape.

In the development of this standard careful consideration was given to current practices, existing equipment and supplies, and the broadest possible acceptance while providing a basis for future improvement in the use of the medium.

This standard was approved as an AN Standard by the American National Standards Institute on _____.

Suggestions for improvement derived from the use of this standard will be welcome. They should be sent to the American National Standards Institute, 1430 Broadway, New York, New York 10018.

The ANSI Committee on Computers and Information Processing at the time of approval of this standard had the following membership:

The Technical Committee on Magnetic Tape, X3B5, which developed this standard, had the following membership:

Proposals developed by an ANSI Technical Committee are the result of individual effort though the members are variously affiliated.

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Approved For Release 2002/05/17 : CIA-RDP83T00573R000600200017-9

AMERICAN NATIONAL STANDARD

Recorded Magnetic Tape Cartridge for Information Interchange
4-Track, 0.250 inch (6.30mm), 1600 BPI (63bpmm), Phase Encoded

1. Scope and Purpose

1.1 Scope

This American National Standard is intended to provide a format and recording standard for a 0.250 inch (6.30mm) wide, 4-track, magnetic tape in a cartridge to be used for information interchange between information processing systems, communication systems, and associated equipment utilizing the American National Standard Code for Information Interchange, X3.4-1968 (ASCII) and amendments thereto. This standard refers solely to recording on the 0.250 inch (6.30mm) magnetic tape cartridge and supports ANSI Standards and complements the American National Standard Unrecorded 0.250 inch (6.30mm) Wide Magnetic Tape Cartridge for Information Interchange (X3.__-19xx in preparation, presently X3B5/75-43) where the following sections are dealt with in detail: general requirements, definition, tape and cartridge, physical and magnetic requirements, speed requirements, and write enable feature. Compliance with the unrecorded standard is a requirement for information interchange.

CAUTION NOTICE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the publisher.

No representation or warranty is made or implied that this is the only license that may be required to avoid infringement in the use of this standard.

1.2 Purpose

1.2.1 This standard defines the requirements and supporting test methods necessary to ensure interchange at acceptable performance levels. It is distinct from a specification in that it delineates a minimum of restrictions consistent with compatibility in interchange transactions.

1.2.2 Wherever feasible, quantitative performance levels which will be met or exceeded as a result of conformance to this standard are given. Quantitative limits for some of the requirements falling within the scope of this standard are not stated but are left to agreement between interchange parties. Standard test methods and measurement procedures shall be used to establish such quantities.

1.2.3 Conversions of toleranced dimensions from U.S. customary engineering units (similar to British Imperial units) to SI units have been done in this standard according to ISO R 370 Method B[1]. U.S. engineering units are the original dimensions in this standard.

1.2.4 Except as indicated in 1.2.2 above, interchange parties conforming to the applicable standards should be able to achieve compatibility without need for additional exchange of technical information.

2. Definitions and Explanations of Terms.

For the purpose of this standard, the following definitions apply:

2.1 Magnetic Tape Cartridge. A cartridge containing 0.250 inch (6.30mm) wide magnetic tape wound on two coplanar hubs with an internal drive belt to transport the tape between the hubs. (See Figure 1)

2.2 Flux Reversal. The position of a flux reversal is defined as that point which exhibits the maximum free space flux density normal to the tape surface.

2.3 Density. The number of data bit flux reversals per unit length of recorded track, exclusive of phase flux reversals; usually expressed in bits per inch.

2.4 Recorded Block. A group of contiguously recorded bits which extend from one interblock gap to the next interblock gap. This includes the data bits, CRC, and synchronizing bits, such as preamble and postamble (See Figure 3.)

2.5 Data Block. A group of contiguously recorded bits, less CRC and synchronizing bits, such as preambles and postambles, considered and transported as a unit containing one or more logical records, or portions of logical records.

2.6 Interblock Gap. A DC erased section of tape separating blocks of information.

2.7 In Contact. An operating condition in which the oxide side of a tape is in physical contact with a magnetic head.

2.8 Control Block (Tape Mark). A special control block recorded on magnetic tape to serve as a separator between files and file labels, or to define the end of recorded data.

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[1] In the corresponding national standards of ISO member nations, additional rounding may be done to produce preferred values. These values usually lie within the original tolerance ranges.

2.9 Reference Alignment Cartridge. A cartridge containing tape on which continuous information has been recorded. The reference alignment cartridge has been optimized for perpendicularity of the written flux transition to the cartridge positioning plane.

2.10 Preamble. A special sequence of bits recorded at the beginning of each recorded block.

2.11 Postamble. A special sequence of bits recorded at the end of each recorded block.

2.12 CRC Character. The CRC is a 16 bit cyclic redundancy check character that is written after the data and preceding the postamble of each block for the purpose of error detection.

2.13 Beginning of Tape (BOT) Marker. The BOT marker is a set of two holes punched in the tape. There are three sets of holes provided, the innermost of which is used for the purpose of identifying the storage position for the cartridge. In the storage position, all of the permissible recording area is wound on the supply hub and is protected by at least one layer of tape. Cartridges to be interchanged shall be rewound to the storage position prior to interchange. The additional sets of holes are used to insure reliability of detection. (See Figure 4.)

2.14 End of Tape (EOT) Marker. The EOT marker is a single hole punched in the tape. There are three such holes along a single line. The first to pass the photo sensor during forward operation indicates that the permissible recording area has been exceeded. The additional sets of holes are used to insure reliability of detection. (See Figure 4.)

2.15 Load Point (LP) Marker. The LP marker is one hole punched in the tape to indicate the beginning of the permissible recording area in the forward direction. (See Figure 4.)

2.16 Early Warning (EW) Marker. The EW marker is one hole punched in the tape between recorded tracks for the purpose of indicating the approaching end of the permissible recording area in the forward direction. Recording must halt before the EOT marker is sensed. (See Figure 4.)

2.17 Amplitude Reference Tape. A tape selected for a given property to establish the reference output signal level when recorded with continuous "ones" at 3200 frpi (126 frpmm).

2.18 Standard Reference Current. The minimum write current which when applied to the amplitude reference tape causes an output signal equal to 95% of the maximum output at 3200 frpi (126 frpmm.)

2.19 Standard Reference Amplitude. The peak-to-peak output level which is read from the amplitude reference tape when written at 3200 frpi (126 frpmm) with a write current which is 1.5 times the value of the standard reference current.

2.20 Track. A longitudinal area on the tape along which a series of magnetic signals may be recorded.

3. Recording.

3.1 Method. The method of recording shall be phase encoding. Each data bit requires a reversal of flux polarity in a given direction for a logical "1", and in the opposite direction for a logical "0". Phase flux reversals will occur at the nominal midpoint between data bits in order to permit the proper polarity shift for the following data bit. "Self-clocking" is attained in this recording method through the consistent occurrence of flux reversals for each data bit, 1600 times per inch (63 times per mm). The erasing process described in Section 3.6 forms part of the recording procedure.

3.1.1 Data Bit "1". A "1" data bit is defined as a flux reversal to the same polarity as the interblock gap when reading in the forward direction.

3.1.2 Data Bit "0". A "0" data bit is defined as a flux reversal to the polarity that is opposite to that of the interblock gap when reading in the forward direction.

3.1.3 Phase Flux Reversals. Flux reversals that occur at the nominal midpoint between successive "1" bits or between successive "0" bits to establish proper polarity for the following data bit are called phase flux reversals.

3.2 Equipment. The equipment and cartridge used for interchange must satisfy the requirements of Sections 3.3 to 3.6 inclusive. All signal measurements are made at a point in the read chain where the amplitude is proportional to the rate of change of the flux in the read head. For the purpose of relating bit spacing along the tape to cartridge driving speed, the ratio of tape speed to the surface speed of the belt capstan shall be assumed to be exactly 0.76.

3.3 Density. The nominal recording density shall be 1600 bits per inch (63 bpmm). Density statements in bits per inch (bits per mm) are always exclusive of phase flux reversals.

3.3.1 Bit Spacing. The nominal bit spacing exclusive of phase flux reversals is 625 microinches (15.9um).

3.3.2 Long Term Average Bit Spacing. The long term average bit spacing shall be within ± 3% of the nominal spacing. This average shall be measured over a minimum tape length of 150 inches (3.81m).

3.3.3 Short Term Average Bit Spacing. The short term average bit spacing referred to a particular bit-spacing is the average of the preceding four bit-spacings.

The short term average bit spacing, exclusive of the effects of Section 3.4, shall be within ± 7% of the long term average bit spacing. In addition, the short term average bit spacing shall not change at a greater rate than 2% per bit.

3.4 Flux Reversal Spacing. To determine the instantaneous spacing between any two flux transitions, the following two paragraphs must be taken together:

3.4.1 Data Bit to Data Bit Tolerance. The spacing between successive data bits without an intervening phase flux reversal shall be between 88% and 105% of the short term average bit spacing.

The spacing between successive data bits with an intervening phase flux reversal shall be between 95% and 112% of the short term average bit spacing.

3.4.2 Data Bit to Phase Flux Reversal Tolerance. The spacing between a data bit and any adjacent phase flux reversal shall be between 44% and 56% of the short term average bit spacing.

3.5 Signal Amplitude. The following apply to writing and reading in contact.

3.5.1 Average Signal Amplitude. The average peak-to-peak signal amplitude of the interchange tape at 3200 frpi (126 frpmm) shall deviate no more than +50% -35% from the standard reference amplitude. Averaging shall be done over a minimum of 3200 flux reversals, which, for interchange cartridges, may be segmented into groups.

3.5.2 Maximum Signal Amplitude. The peak-to-peak signal amplitude at 1600 frpi (63 frpmm) shall be less than three times the standard reference amplitude.

3.5.3 Minimum Signal Amplitude. No tape when interchanged shall contain any adjacent flux reversals whose peak-to-peak signal amplitude is less than 20% of the standard reference amplitude.

3.5.4 Azimuth Alignment. When adjusted for maximum output, the read head azimuth angles for a reference alignment cartridge and for the interchange cartridge shall not differ by more than ± 10 minutes.

3.5.5 Rejected Regions. A rejected region is an area of tape extending across the track width and not more than 1.0 inch (25,4mm) in length which exhibits permanent dropouts on two consecutive passes. The number of rejected regions in an interchange environment is a matter of agreement between interchange parties.

3.6 Erase.

3.6.1 Erase Direction. The tape shall be magnetized so that the beginning of tape is a North-seeking pole.

3.6.2 Erase Function. Erasure, whether by the write head or the erase head, shall insure that the level of the read back signal amplitude is below 3% of the average signal amplitude at 3200 frpi (126 frpmm).

4. Format.

4.1. Number of Tracks. There will be up to four tracks. Each track is a data track and will be independent of the other tracks. Individual read/write units may provide one, two, or four tracks. The number one track must be readable on all units. The number two track is readable on either two or four track units (i.e., track positions, track widths, and erased areas must be compatible between units with a varying number of tracks).

4.2 Use of Tracks. Each track shall be written in serial fashion starting near the BOT and continuing toward the EOT, with a rewind to BOT before initiating writing on the next track. All tracks are primarily data tracks, however, if one or more tracks are used for other than data, the number one track must always be a data track. Track locations and designations are shown in Figure 2.

4.3 Byte and Code Requirements.

4.3.1 Byte Size. The system shall be capable of reading and writing an 8 bit byte. The American National Standard Code for Information Interchange 7-bit coded character set (X3.4-1968) is recorded in the 7 least significant bit-positions of an eight bit byte. The 8th position is always a zero bit.

4.3.2 Bit Sequence. Bits are recorded on the tape in serial fashion. The low order data bit (b1) is recorded first, then the next data bit (b2), and so on to the high order data bit (b8). The data bits of ASCII are numbered b8, b7, b6, b5, b4, b3, b2, and b1 from the high order to low order.

4.4 Gaps.

4.4.1 Initial Gap. The initial gap is the distance between the load point and the first bit of the first recorded block on tape. The minimum distance is 6.0 inches (152.4mm).

4.4.2 Interblock Gap. For data interchange, the length of the interblock gap shall be a minimum of 1.2 inches (30,5mm), and a maximum of 48 inches (1219 mm). Preambles and postambles are not considered as part of the IBG.

4.4.3 Gap Polarity. The polarity of all gaps shall be established by the erase function in the direction specified in Section 3.6.1.

4.4.4 Integrity of Gaps

The gaps shall be DC erased. Immediately before and after each block there shall be a length of at least 0.09 in (2.3 mm) in which, exclusive of residual edge signals, there is no flux discontinuity capable of producing a read signal of more than 10% of half the Standard Reference Amplitude.

In the remaining part of the gap one burst of spurious transitions can be tolerated, provided that the total number of transitions are 7 or less.

4.5 Block Length.

4.5.1 Minimum Data Block Length. The minimum data block is that group of bits, exclusive of preamble and postamble, and CRC, that can be considered a valid block. This minimum block length, exclusive of the tape mark, is six 8 bit data bytes.

4.5.2 Maximum Data Block Length. The maximum data block length is 2048 bytes.

4.5.3 Preamble. Preceding the data in each block a preamble shall be written consisting of 15 zero bits followed by a one-bit. (See Figure 3.) The preamble may be used to establish a timing sequence so that data can be read in the forward direction.

4.5.4 Postamble. Following the data and the CRC character in each block, a postamble shall be written consisting of one one-bit followed by 15 zero bits. (See Figure 3.) The postamble may be used to establish a timing sequence so that data may be read in the reverse direction.

4.6 Control Block (Tape Mark). The control block (tape mark) shall consist of a preamble, two bytes of eight "zero" bits each, and a postamble.

4.7 CRC Character. A 16 bit CRC shall be written in each data block following the data and immediately preceding the postamble. The CRC is generated by the polynomial $X^{16} + X^{15} + X^2 + 1$.

4.8 Useable Recording Area. All data to be interchanged shall be written within the useable recording area as defined in Figure 4.

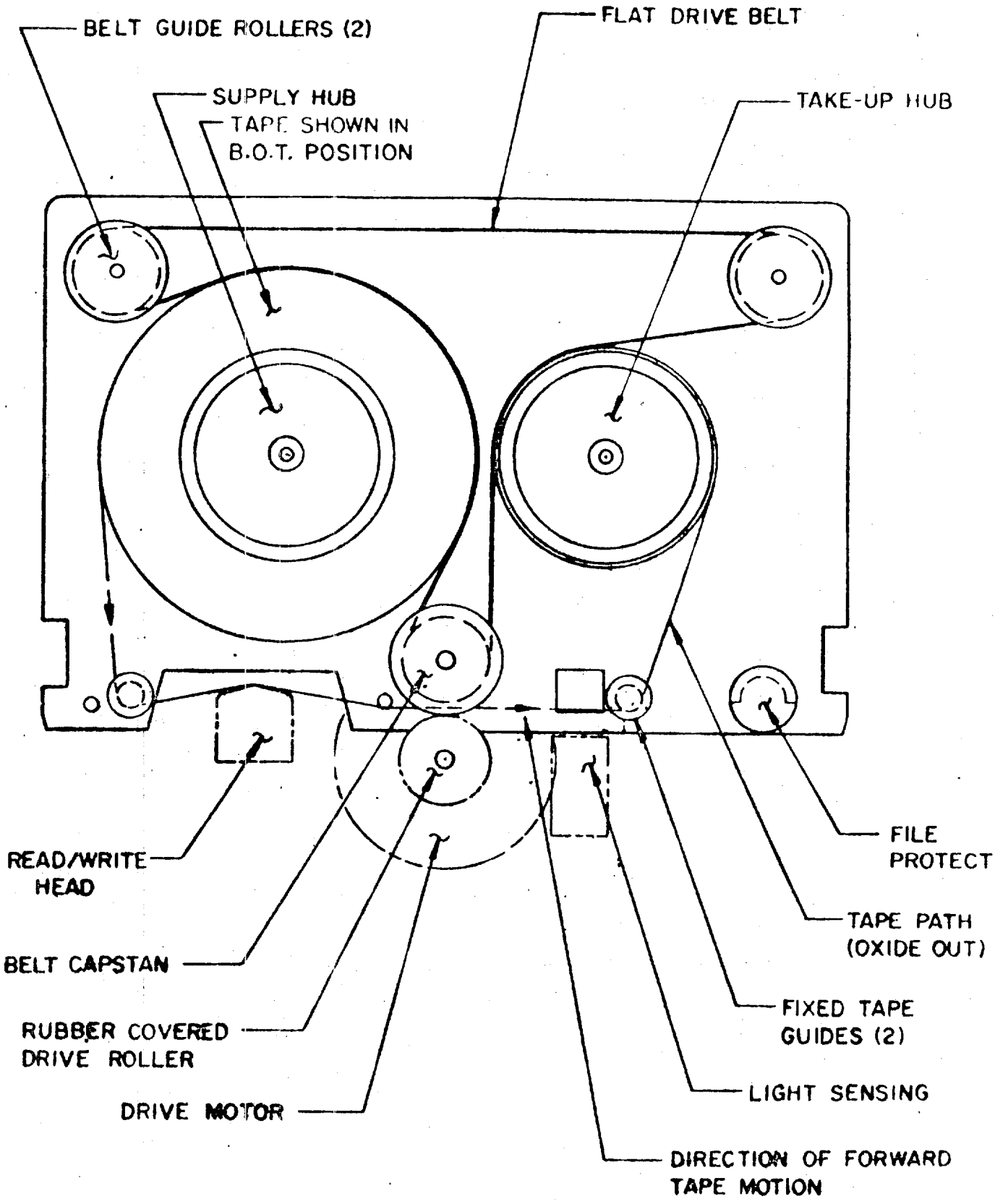
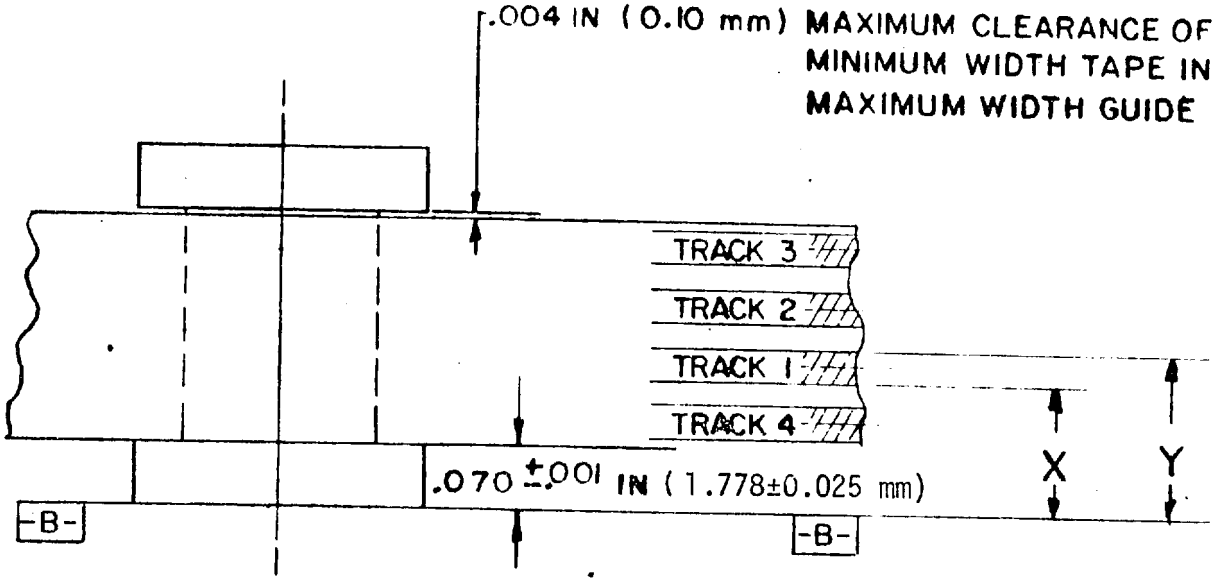


FIGURE 1. CARTRIDGE DIAGRAM



TRACK DIMENSIONS TO CARTRIDGE REFERENCE

TRACK	INCHES				MILLIMETERS			
	DIMENSION X		DIMENSION Y		DIMENSION X		DIMENSION Y	
	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
1	.146	.130	.194	.178	3.71	3.30	4.93	4.52
2	.210	.194	.258	.242	5.33	4.93	6.55	6.15
3	.274	.258	.322	.306	6.96	6.55	8.18	7.77
4	.082	.066	.130	.114	2.08	1.68	3.30	2.90

FIGURE 2. TAPE GUIDE & TRACK DIMENSIONS

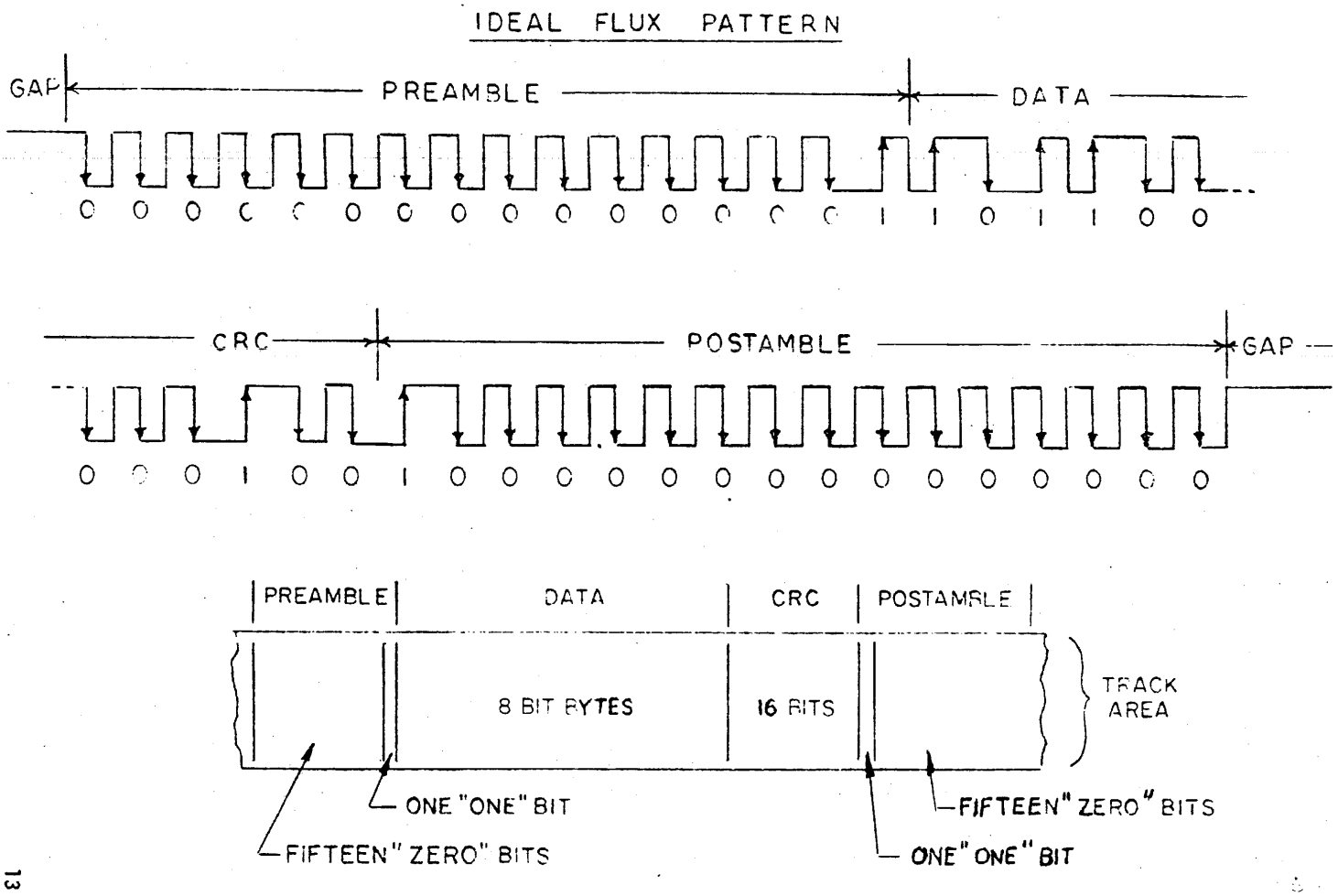
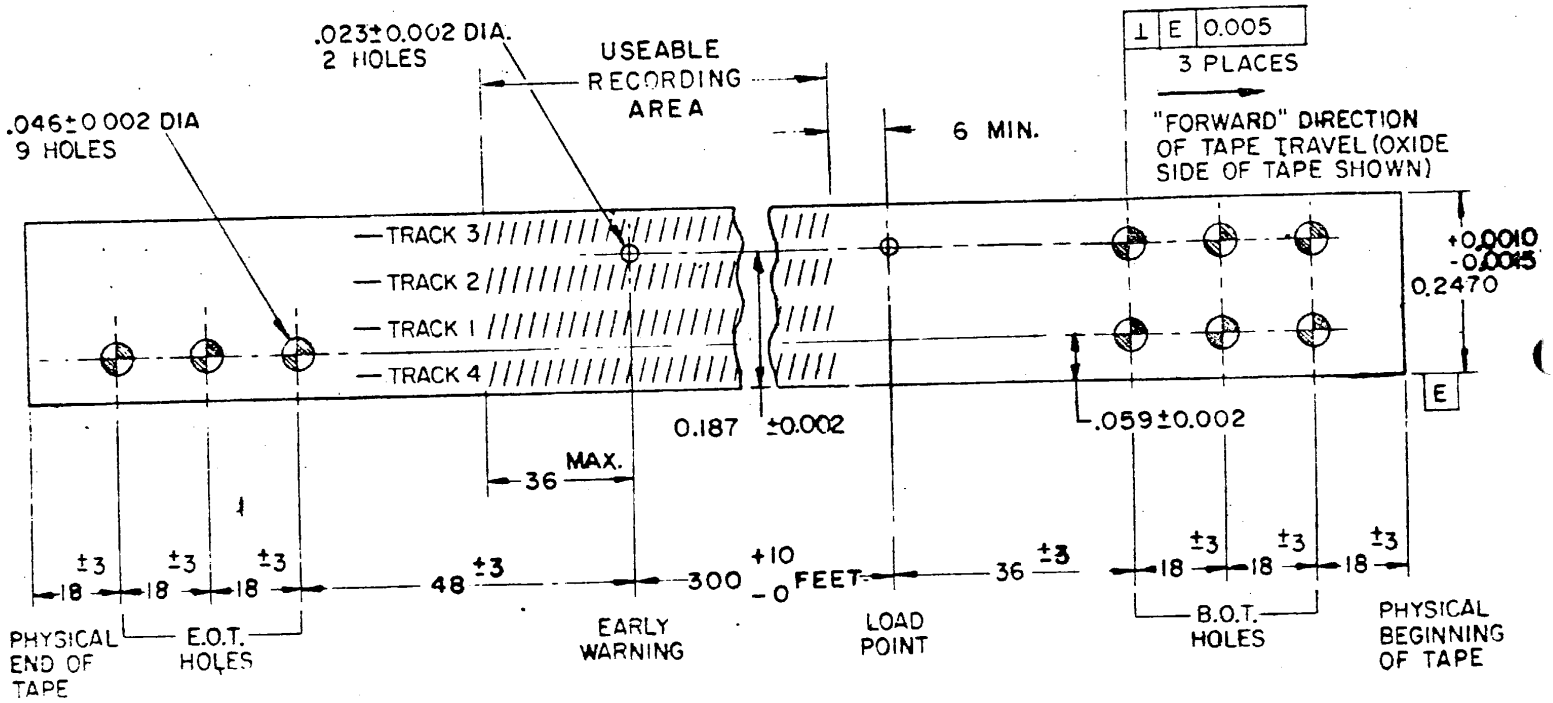


FIGURE 3. RECORDED BLOCK



TOLERANCE AS NOTED
DIMENSIONS IN INCHES

FIGURE 4 TAPE POSITION HOLES & RECORDING FORMAT

REV 2/21/75

Federal Information
Processing Standards Publication

Announcing the Standard for
MAGNETIC TAPE CASSETTE FOR INFORMATION INTERCHANGE
(CO-PLANAR, 3.81 mm (0.150 in), 32 bpmm (800 bpi), PE)

Federal Information Processing Standards Publications are issued by the National Bureau of Standards pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), Executive Order 11717 (38 FR 12315), dated May 11, 1973), and Part 6 of Title 15 CFR (Code of Federal Regulations).

Name of Standard. Magnetic Tape Cassette for Information Interchange (Co-Planar, 3.81 mm (0.150 in), 32 bpmm (800 bpi), PE) (FIPS PUB __).

Category of Standard. Hardware Standard, Interchange codes and media.

Explanation. This standard specifies the physical, magnetic, and recorded characteristics of a 3.81 mm (0.150 in) magnetic tape cassette in order to provide for data interchange between information processing systems at a recording density of 32 bits per millimeter (800 bits per inch) using phase encoding techniques. The magnetic tape cassette consists of a twin hub co-planar type cassette containing 3.81 mm (0.150 in) wide magnetic tape. This standard is one of a series of Federal Standards implementing the Federal Standard Code for Information Interchange (FIPS 1) on magnetic tape media.

Approving Authority. Secretary of Commerce.

Maintenance Agency. Department of Commerce, National Bureau of Standards (Institute for Computer Sciences and Technology).

Cross Index.

a. American National Standard X3.48-1976, Magnetic Tape Cassette for Information Interchange (Co-Planar, 3.81 mm (0.150 in), 32 bpmm (800 bpi), PE).

b. FIPS PUB 1, Federal Standard Code for Information Interchange.

c. FIPS PUB 35, Code Extension Techniques in 7 or 8 Bits.

d. At the time of publication of this FIPS PUB, a standard for dual track complementary return-to-bias four state recording (CRB) for a 3.81 mm (0.150 in) magnetic tape cassette was being developed by the American National Standards Institute. This voluntary industry standard, when available, will be considered for Federal adoption as a FIPS.

Applicability. This standard is applicable to the acquisition and use to all magnetic tape cassette recording and reproducing equipments employing 3.81 millimeter (0.150 inch) wide magnetic tape at recording densities of 32 bits per millimeter (800 bits per inch) using phase encoding. Federal information processing systems employing such equipment, including associated software, shall provide the capability to accept and generate recorded magnetic tape cassettes in compliance with the requirements set forth in this standard.

Specifications. This standard adopts the requirements set forth in the American National Standard X3.48-1976, Magnetic Tape Cassette for Information Interchange (Co-Planar, 3.81 mm (0.150 in), 32 bpmm (800 bpi), PE).

Implementation Schedule. All applicable equipment ordered on or after the date of this FIPS PUB must be in conformance with this standard unless a waiver has been obtained in accordance with the procedure described below.

Federal departments and agencies are responsible for issuing specific internal implementation instructions for the use by this standard by their organizational units and for assuring that copies of this FIPS PUB and its associated technical specification (American National Standard X3.48-1976) are made available to all effected parties.

Special Information. Federal standards and/or specifications for unrecorded magnetic tape cassettes will be developed and issued by the General Services Administration. Until such time as these are available, American National Standard X3.48-1976, Magnetic Tape Cassette for Information Interchange (Co-Planar, 3.81 mm (0.150 in), 32 bpmm (800 bpi), PE), should be cited in Federal procurements.

Also, GSA will provide terminology for use of this standard in Federal ADP acquisitions. This terminology will be incorporated in the Federal Property Management Regulations (Title 41, Subtitle C, Part 101, Subpart 101-32.13, Code of Federal Regulations).

Qualifications. None.

Waiver Procedures. (The approval and processing of waivers to Federal Information Processing Standards is currently being reviewed by the Department of Commerce and will be provided in the printed version of this FIPS PUB.)

Where to Obtain Copies of the Specifications.

(To be completed by NBS.)

BSR X3.48

(Revision of X3B5/75-03
and X3/75-05)

X3B5/75-55
1975 Oct 1
Project 213

Seventh Draft

Proposed
American National Standard

Magnetic Tape Cassette for Information Interchange (Co-Planar, 3.81 mm [0.150 in], 32 bpmm [800 CPI], PE)

This 7th Draft is the result of X3B5 actions to more closely align the domestic proposal with the corresponding international proposal, ISO/DIS 3407. Changes from the 6th Draft, which had earlier been approved by X3, are noted by marginal rulings.

X3 members are given 30 days in which to register objections to these changes. If no objections are received, this draft will be submitted to ANSI for final approval. Objections should be submitted not later than 1976 February 10, addressed to:

CBEMA/Secretary X3
1828 "L" ST NW
Washington DC 20036

Prepared by
Technical Committee X3B5 - Magnetic Tape Cassettes

American National Standards Committee
X3 - Computers and Information Processing

Secretariat: Computer and Business Equipment Manufacturers Association

FOREWORD

(This Foreword is not a part of American National Standard Magnetic Tape Cassettes for Information Interchange, X3.48-197_)

This standard presents the minimum requirements for mechanical and magnetic interchangeability of 0.150 inch wide magnetic tape and the associated tape cassette between information processing systems, communication systems and associated equipment using the ASCII X3.4-1968 and Amendments thereto on magnetic tape at 32 bits per mm (800 bpi) using phase encoding techniques.

Subsequent standards may specify higher densities, other cassettes with wider and thicker tapes, will define more fully the physical magnetic tape and will specify a standard record format and labels. Other recording formats may also be specified.

The X3B5 Task Group which developed this document consists of a group of experienced and qualified specialists on recording of digital information on magnetic tape.

In the development of this standard, careful consideration was given to current practices, existing equipment and supplies, and the broadest possible acceptance while providing a basis for future improvement in the use of the medium.

This standard was approved as an American National Standard by the American National Standards Institute on

Suggestions for improvement derived from use of this Standard will be welcome. They should be sent to the American National Standards Institute, Inc., 1430 Broadway, New York 10018.

At the time the proposal was developed and processed through the X3 Committee (Computers and Information Processing), the membership was :

The Task Group on Magnetic Tape, X3B5 which developed this standard had the following personnel:

Proposals developed by an ANSI Subcommittee or Task Group are the result of individual effort, though the members are variously affiliated.

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FIGURES

APPENDICES

1. Scope

1.1 To set a standard for a 3.81mm (0.150 in) magnetic tape cassette to provide data interchange and physical interchangeability between information processing systems utilizing the American National Standard Code for Information Interchange (ASCII X3.4-1968) and amendments thereto. The cassette is of the twin hub co-planar type, loaded with a 3.81mm (0.150 in) wide magnetic tape for digital recording using the 31.5 bits per mm (800 bpi) phase encoding method. The direction of magnetization is in the longitudinal direction of the tape.

NOTE: Throughout the remainder of the standard for the sake of simplicity, the recording density is stated as 32 bpmm, (800 bpi) nominal.

1.2 The Standard applies to cassettes and data used for interchange. Where it applies for testing only, this is specifically stated.

2. Definitions and Explanation of Terms

For the purpose of this Standard, the following definitions apply:

2.1 Magnetic Tape

A tape which accepts and retains magnetic signals intended for input/output and storage purposes of information processing and associated systems.

2.2 Reference Tape Cassette

A tape cassette arbitrarily selected for a given property for calibrating purposes.

2.3 Secondary Reference Tape Cassette

A tape cassette intended for routine calibrating purposes, the performance of which is known and stated in relation to that of the Reference Tape Cassette.

(Former section 2.4 deleted)

2.4 Reference Field

The minimum field which, when applied to the Reference Recording Field Tape Cassette, causes a signal output equal to 95% of the maximum signal output at the specified test packing density (see 4.2).

2.5 Test Recording Current

A recording current between 145% and 155% of the current required to produce the Reference Field.

2.6 Signal Amplitude Reference Tape Cassette

A reference tape cassette selected as a standard for signal amplitude.

NOTE: A Master Standard (Computer Amplitude) has been established at the U.S. National Bureau of Standards based on reference tape cassettes and heads as the result of work by national standardization organizations and national laboratories coordinated by the U.S. National Bureau of Standards. Secondary signal amplitude reference tape cassettes are available from NBS under part number SRM 1600.

2.7 Standard Reference Amplitude

The Standard Reference Amplitude is the average peak-to-peak signal amplitude derived from the Signal Amplitude Reference Tape Cassette, at the density of 63 ftpmm (1600 ftpi) using the Test Recording Current (see 2.5). The signal amplitude shall be averaged over 4000 flux transitions.

2.8 Average Signal Amplitude

The average peak-to-peak value of the signal output measured over at least 4000 flux transitions.

2.9 In Contact

An operating condition in which the magnetic surface of a tape is in physical contact with a magnetic head.

2.10 Track

A longitudinal area of the tape along which a series of magnetic signals may be recorded.

2.11 Bit Density

The number of bit flux transitions per unit length of track.

2.12 Position of Flux Transitions

The position of a flux transition is defined as that which exhibits the maximum free space flux density normal to the tape surface.

2.13 Leader

Non-magnetic transparent tapes joined to each end of the magnetic tape, for reasons of strength and convenience.

2.14 Erasing Field

A unidirectional field of sufficient strength to remove the signals from the tape.

2.15 Print Through

Any unwanted signals induced in one layer of tape by the field of a deliberately recorded signal in an adjacent layer or layers.

2.16 Reference Alignment Cassette

A cassette containing tape on which continuous information has been recorded, where the optimum playback head gap alignment does not differ by more than $\pm 3'$ from the vertical on the cassette support plane. (Currently these cassettes are available with wavelengths of 7.5μm [295 microinch] and 4.75um [187 microinch]).

2.17 Typical Field

The minimum field characteristic of each tape, which, when applied to the tape under test, causes a signal output equal to 95% of the maximum signal output at the specified test packing density.

2.18 Tape Cassette Center Line

In Figures 1 through 6, the center line of the cassette is defined as a line perpendicular to the Prime Reference Line and located midway between the centers of the two Reference Holes (Figure 4).

3. Environment and Transportation

3.1 Testing Environment

Tests and measurements made on the cassette to check the requirements of this Standard shall be carried out under the following conditions:

Temperature:	23 ± 2°C (73 ± 5°F)
RH:	40% to 60%
Conditioning before testing:	24 hours minimum

3.2 Operating Environment

Cassettes used for data interchange shall be operated under the following conditions:

Temperature:	10°C to 45°C (50°F to 113°F)
RH:	20% to 80%
Wet bulb temperature:	Less than 26°C (79°F)

The temperature is to be measured in the air immediately surrounding the cassette. Rapid temperature variations should be avoided. There shall be no deposit of moisture on or in the cassette.

3.3 Transportation and Storage Environment

During transportation and storage, it is recommended that recorded cassettes are kept within the following conditions:

Temperature:	4°C to 50°C (40°F to 122°F)
RH:	20% to 80%

NOTE: Cassettes which have been exposed to temperatures exceeding the storage temperature range may exhibit degraded performance characteristics. Such cassettes should be subjected to a conditioning period of not less than 24 hours within the operating environment prior to use.

3.4 Transportation

Responsibility for ensuring that adequate precautions are taken during shipment shall be with the sender. During transport, the reels of tapes shall be blocked to prevent any tendency to unwind. For transport, a rigid container free from dust or extraneous matter shall be used. The final package must have a clean interior and construction, preventing ingress of dust and water. It is recommended that a space of not less than 80mm (3.15 in.) exist between cassette and outer surface of the final container so that risk of damage due to stray magnetic fields will be negligible.

4. Characteristics of Tape

The tape shall consist of a base material (e.g. oriented polyethylene terephthalate film or equivalent) coated on one side with a strong and flexible layer of ferromagnetic material dispersed in a suitable binder. The magnetic tape shall be continuous and splice-free. Tape or cassette components which will ignite from a match flame and when so ignited will continue to burn in a still carbon dioxide atmosphere shall not be used. Tape or cassette components which may cause bodily harm by contact, inhalation or ingestion during normal use of the cassette shall not be used.

4.1 Mechanical Properties

4.1.1 Tape and Leader Width and Tolerance --

The width of tape and leader shall be:

$3.81\ ^{+0}_{-0.05}$ mm ($0.150\ ^{+0}_{-0.002}$ in.)

4.1.2 Tape and Leader Length --

4.1.2.1 Tape Length --

The length of the splice-free tape shall be:

$86\ ^{+4}_{-0}$ m ($282\ ^{+13}_{-0}$ ft)

4.1.2.2 Leader Length --

The length of the leader tape shall be such that the distance from the cassette face to the beginning of the magnetic tape is 500 ±50mm (19.68 ±2.00in) when the leader tape is pulled out of the cassette through the opening nearest to the empty reel.

4.1.3 Tape and Leader Thickness --

4.1.3.1 Thickness of Tape --

The overall thickness of tape and coating shall be maximum 19μm (750 microinch) minimum 15μm (600 microinch) with a coating thickness of 6μm (240 microinch) maximum.

4.1.3.2 Thickness of Leader --

The thickness of the leader shall be 38μm (1500 microinch) maximum.

4.1.4 Markers --

4.1.4.1 The magnetic tape shall be provided with a beginning-of-tape and an end-of-tape marker (BOT and EOT).

4.1.4.2 Dimensions --

The markers shall be circular holes having a diameter of 0.60 ± 0.05mm (0.0237 ± 0.0020in).

4.1.4.3 Position --

The distance of the marker centers from the physical beginning and end of the magnetic tape (for BOT and EOT respectively) shall be 450 ± 30mm (17.7 ± 1.2 in). The distance between tape centerline and marker centerline shall be less than 0.1mm (0.0039 in).

4.1.5 Light Transmittance --

4.1.5.1 Light transmittance of tape --

The tape and the backing tape shall each have a light transmittance of less than 1% measured according to Appendix B.

4.1.5.2 Light transmittance of leader --

The leader tape shall transmit 75% or more light, measured according to Appendix B.

4.1.6 Elastoplastic properties --

4.1.6.1 The elastic properties of the tape shall be such that when subjected to a tension of 0.5 N (0.112 lb) for a period of three minutes under any combination of temperature and relative humidity within the ranges of 3.1, the elongation shall be between 0.08 and 0.50%.

4.1.6.2 The elastoplastic properties of the tape shall be such that when subjected to a tension of 3 N (0.67 lb) for a period of three minutes under temperature and humidity conditions as mentioned in 3.1, the (permanent) elongation measured with negligible tension after a second three minutes interval shall be less than 1.0%.

4.1.6.3 The elastic properties of the tape shall be such that its tensile yield force - defined as the force required to elongate a sample by 3% - shall be at least 4.5 N (1.01 lb).

Procedure: Use a static weighing-constant rate of grip separation tester capable of indicating the load to an accuracy of ±2%. Clamp a specimen of tape at least 180mm (7 in) in length with an initial 100mm (4 in) separation between jaws. Elongate the specimen at a rate of 50mm (2 in) per minute until minimum elongation of 10% is reached. The force required to produce an elongation of 3% is the tensile yield force.

4.1.6.4 The elastic properties of the leader shall be such that when subjected to a tension of 1.0 N (0.225 lb) for a period of three minutes under temperature and humidity conditions as mentioned in 3.1, the elongation shall be between 0.08 and 0.50%.

4.1.7 Longitudinal Curvature --

There shall be a minimum radius of curvature for the edge of the tape, defined and tested by allowing a 1m (39 in) length of tape to unroll and assume its

natural curvature on a flat surface. The minimum radius shall be 33m (108 feet) which, if measured over an arc of a circle, corresponds to a deviation of 3.8mm from a 1m chord (0.15 in from a 39 in chord).

4.1.8 Tape-to-Leader Connection --

4.1.8.1 Dimensions --

If a splicing tape is used, this shall not extend more than 18mm (0.71 in) from the gap between leader and tape. The actual gap itself shall be 0.5mm (0.02 in) maximum. An overlap of 0.05mm (0.002 in) maximum is allowed.
The thickness of the splicing tape shall be 50µm (0.002 in) maximum.

4.1.8.2 Tape-to-Leader Alignment --

At the area of the splice, there shall be no lateral discontinuity greater than 100µm (0.004 in). The total width of magnetic tape-leader-splicing tape junction shall be no more than 3.86 mm (0.152 in).

4.1.8.3 Strength --

After being subjected to a longitudinal static force of 2N (0.45 lb) for 24 hours under the conditions of 3.2, the connection shall meet the requirements of 4.1.8.1.

4.1.9 Layer-to-Layer Adhesion --

Layer-to-layer adhesion must be sufficiently low to meet the test of Appendix A.

4.2 Tests of Magnetic Properties

The magnetic properties of the tape are defined by the testing requirements given in this section.

4.2.1 Test Density --

Tape shall be tested at 63 ftpmm (1600 ftpi) nominal.

4.2.2 Typical Field --

The typical field of the tape under test shall be within ±20% of the reference field.

4.2.3 Average Signal Amplitude --

When a tape has been recorded with the Test Recording Current, then played back on a system which has been calibrated by means of a Signal Amplitude Reference Tape Cassette recorded under the same conditions, the Average Signal Amplitude of the tape under test shall be within $^{+25\%}_{-10\%}$ of the Standard Reference Amplitude. When performing this test, the output signal shall be measured for the same relative pass for both tapes, i.e., read-while-write or read-on-first-pass-after-write.

4.2.4 Ease of Erasure --

When a tape has been recorded with the Test Recording Current, and then passed through a longitudinal steady erasure field of 79500 A per m (1000 oersteds) the Average Signal Amplitude of the remaining unwanted signal shall not exceed 3% of the Standard Reference Amplitude. The erasure field shall be reasonably uniform; e.g., the field in the middle of a solenoid. This measurement shall be made with a band pass filter passing at least the first three harmonics.

4.2.5 Test for Drop-Outs and Drop-Ins --

These tests shall be carried out in the in-contact condition and over the entire usable recording area (see Fig. 7) which shall, in length, extend from 350mm (13.8 in) before the BOT-marker to 350mm (13.8 in) beyond the EOT-marker, and in width over the track widths as defined in 7.2.

When performing these tests, the output signal shall be measured on the same relative pass for both the Signal Amplitude Reference Tape Cassette and the tape under test; i.e., read-while-write or read-on-first-pass-after-write.

4.2.5.1 Drop-Outs --

When a tape has been recorded with the Test Recording Current, any playback signal, when measured base-to-peak, which is less than 50% of half the Standard Reference Amplitude is a drop-out.

4.2.5.2 Drop-Ins --

When a tape has been recorded with a constant recording current equivalent to the Test Recording Current, any playback signal, when measured base-to-peak, which exceeds 10% of half the Standard Reference Amplitude, is a drop-in.

4.2.6 Rejected Regions --

A rejected region is an area of tape extending across the width of either tracks and not more than 10mm (0.4 in) in length, which, on two consecutive tests, exhibits drop-outs or drop-ins. (See 6.6). The acceptable number of rejected regions in an interchange environment is a matter of agreement between interchange parties.

4.2.7 Print-Through --

A tape for testing shall be written with a suitable pattern using the test recording current, rewound and stored for a minimum of 16 hours at 60°C (140°F). At the end of this period the measured print-through signal shall not exceed 2% of the Standard Reference Amplitude. As the decay of the print-through signal on a section of tape is extremely rapid after it has been removed from the coil, the time elapsing between the tape leaving the coil and it passing over the test read head shall not exceed 500ms.

4.3 Electrical Surface Resistance

The surface resistance of the tape shall not exceed

10^9 ohms/square

NOTE: Resistance per square -- the surface resistance of a square area of any size, measured between electrodes placed on two opposite sides of the square. The unit of the measurement is the ohm.

5. Tape Cassette

5.1 Identification of Cassette Sides

5.1.1 The cassette has its two sides distinguished and labelled "A" and "B", respectively, corresponding to tracks No. 1 and No. 2 (see Figure 1).

5.1.2 The back surface is provided with two holes whose minimum area, depth and section are indicated in Figure 1. Writing on a track is enabled by closing the outer surface of the corresponding hole. When a closing device other than a plug is used, it must remain attached to the cassette.

5.1.3 The back surface is provided with one slot slightly off-center (see Figure 1). This slot makes it possible to distinguish between the sides "A" and "B", both visually and mechanically.

5.2 Mechanical Characteristics

The mechanical characteristics which define the co-planar tape cassette and which permit physical interchangeability of cassettes on any recorder for data interchange of different manufacture are specified in Figures 1-6. Symmetry about the Tape Cassette Center Line is required (except for the Asymmetrical Slot) with half of the stated tolerances permitted on each side of the Tape Cassette Center Line.

5.3 Basic Specifications

Furthermore, the following basic specifications apply:

5.3.1 Tape Path and Guidance --

Requirements are shown in Figures 2 and 3.

5.3.2 Cassette Support Planes --

The cassette shall be supported by the write/read instrument only where the total cassette thickness is obligatory, i.e., the hatched areas in Figure 5.

5.3.3 Holes in Back Surface --

The position and dimensions of the holes in the back surface are given in Figure 1. The dimensions of the write-enable device, if used, shall be compatible with the hole dimensions as shown in Figure 1 and must be such that it may be installed and removed with reasonable effort and remain seated during normal use. The write-enable device must not protrude beyond the back surface and it must not be recessed more than 1mm (0.039 in). The write-enable device shall at least close the cross hatched area as shown in Figure 1.

5.3.4 Window Area --

The maximum window area shall be in accordance with the dimensions given in Figure 6. The maximum allowable increase in cassette thickness (required, for example, to accommodate marks indicating amount of wound and unwound tape) is given for each support plane.

5.3.5 Withdrawal Force --

The minimum withdrawal force of the leader tape from the hub attachment shall be a static load of 10N (2.25 lb) for a period of 10 minutes.

5.3.6 Tape Winding --

The tape shall be wound on the hubs with the magnetic coating out in such a way that, when recording on Track No. 1, and looking at label A, the tape is unwound in an anticlockwise direction.

5.3.7 Friction Torque of the Full Hub --

The maximum friction torque of the full hub in the cassette shall be 2mN·m (0.28 oz in).

5.3.8 Friction Torque of Both Hubs --

The maximum friction torque of both hubs measured in the cassette itself at the nearly full hub shall be 2.7mN·m (0.38 oz in). With a holdback torque of

0.8. mN·m (0.11 oz in) applied to the nearly empty hub, the required maximum torque to be applied to the nearly full hub shall not exceed 5.5 mN·m (0.78 oz in).

5.3.9 Pressure Pad --

The cassette shall be provided with a pressure pad to hold the magnetic tape against the write/read head. The pressure of the pad upon the head shall be 5 to 15 kPa (11.6 to 34.8 oz/in^2), when the minimum distance between head and reference line lies between 3.1mm (0.122 in) and 3.8mm (0.150 in). This pressure shall be measured on a symmetrically positioned circular cylindrical surface having a radius between 10mm (0.39 in) and infinity (see Figure 2).

Under the above conditions and with 0.8 mN·m (0.11 oz in) holdback torque applied to the nearly empty hub, the required maximum torque applied to the nearly full hub shall not exceed 16 mN·m (2.25 oz in) to start tape motion, and shall not exceed 12.5 mN·m (1.78 oz in) to continue tape motion.

Measured from the centerline of the cassette, the pressure pad shall extend on both sides of this centerline in the direction of tape travel a minimum of 2.5mm (0.098 in) and a maximum of 4mm (0.157 in) Up to the distance of 2.5mm (0.098 in) the pressure requirements still apply. The pressure pad shall be symmetrically positioned, and the distances between pressure pad and cassette support planes surrounding the reference holes shall not exceed 3.5mm (0.138 in). Those values shall also be valid in actual working conditions.

No magnetic material may be used for the cassette construction near the position of the write/read head. No screening shield may be used and the pressure pad and its holder must be of non-magnetic material.

5.3.10 Tape Guides --

The tape touches the cassette at points on either side of the tape head recesses (indicated by arrows U and L). (See Figure 3)

Guides are required at these positions. Between the outer guides (P and S) there must be a closed construction so as to prevent dust entering the cassette.

The guides indicated by the letter L shall be perpendicular to the lower support plane (see 5.3.2). The guides indicated by the letter U shall be perpendicular to the upper support plane.

5.3.11 Transverse Tolerances of Tape Position --

5.3.11.1 Transverse Tolerances without Tape Tension --

The extreme position of the tape in the head region when no tape tension is present shall be limited by means incorporated in the cassette. The distance between cassette support planes surrounding the reference holes and those means shall lie between 3.5mm (0.138 in) and 3.7mm (0.146 in).

5.3.11.2 Transverse Tolerances with Tape Tension --

If the tape is not influenced or touched by any external means (guides, heads, capstans), during wind or rewind, the tape edges shall have a distance of 4.1 $\pm$0.2mm (0.161 $\pm$0.008 in) from the support plane surrounding the reference holes (see Figures 4 and 5). When track No. 1 is being used, the side B outer cassette surface is the reference plane. Conversely, when Track No. 2 is being used, the side A outer cassette surface is the reference plane.

5.4 Labelling of Tape Cassette

5.4.1 Label Area --

The maximum label area shall be in accordance with the dimensions given in Figure 6. The maximum allowable depression in the thickness of the cassette in the label area is given for each support plane.

5.4.2 Interchange --

Suitable labels shall be used for marking contents of cassette. The use of pencil or erasable material is

not allowed. Position and size of labels used shall be less than the provided depression of the label area.

5.4.3 Identification --

The label shall have provisions for the identification of owner, manufacturer, cassette side and interchange label. The label shall indicate:

a. that the cassette is meant for data interchange (see 1, Scope);
b. the use of track 2 (see 7.4);
c. whether 7 or 8 bit coding is used (see 7.7);
d. the method of recording.

5.5 Magnetic Properties of the Cassette Housing

The magnetic properties of the cassette housing shall not impede bulk erasure of the tape by an external device.

6. Recording

6.1 Method of Recording

The method of recording shall be phase encoding, described as follows:

6.1.1 The tape before the first block, the interblock gaps and that part of the tape following the last block written, shall be erased with the same polarity.

This polarity is such that the beginning of the relevant track is a North seeking pole.

This erasing process forms part of the recording procedure.

6.1.2 A ZERO bit is defined as a flux transition to the polarity opposite to that of the interblock gap, when reading in the forward direction.

6.1.3 A ONE bit is defined as a flux transition to the polarity of the interblock gap, when reading in the forward direction.

6.1.4 Additional flux transitions shall be recorded at the nominal midpoints between bit flux transitions as defined in 6.1.2 and 6.1.3 if required, to establish the proper polarity for the succeeding bits. These flux transitions shall be called phase flux transitions.

6.2 Equipment

The equipment and tape used for interchange must satisfy the requirements of 6.3 to 6.8 inclusive.

All signal measurements are made at a point in the read chain where the amplitude is proportional to the rate of change of flux in the read head.

6.3 Density of Recording

6.3.1 The density of recording is 32 bpmm (800 bpi) nominal.

6.3.2 The long term average bit spacing is the spacing between bit flux transitions that have been recorded continuously at a nominal density of 32 ftpmm (800 ftpi) and must be measured over a length of tape of not less than 3.81m (12.5 ft).

The long term average bit spacing shall be within $\pm$4% of the nominal spacing of 31.75µm (1250 microinch).

6.3.3 The short term average bit spacing referred to a particular bit spacing is the average of the preceding four bit spacings.

The short term average bit spacing shall be within the limits of $\pm$5% of the long term average bit spacing.

In addition, the short term average bit spacing shall not change at a rate greater than 2% per bit.

6.4 Flux Transition Spacing

6.4.1 The spacing between successive data bit flux transitions shall not differ by more than 10% from the preceding bit spacing.

6.4.2 The spacing between a phase flux transition and the preceding data bit flux transition shall be between 45% and 55% of the preceding bit spacing.

6.5 Signal Amplitude

6.5.1 Average Signal Amplitude --

6.5.1.1 The average peak-to-peak signal amplitude of the interchanged tape cassette at 63 ftpmm (1600 ftpi) shall not deviate by more than +50%, -35% from the Standard Reference Amplitude. Averaging shall be done over a minimum of 4000 flux transitions, which, for the interchange cassette, may be segmented into blocks.

6.5.1.2 The average peak-to-peak signal amplitude at 32 ftpmm (800 ftpi) nominal shall be less than 2 times the Standard Reference Amplitude.

6.5.1.3 Averaging shall be done on the first-read-pass-after-interchange.

6.5.2 Minimum Signal Amplitude --

No tape cassettes intended for interchange shall contain any adjacent flux transitions whose base-to-peak signal amplitude is less than 35% of half of the Standard Reference Amplitude. This check is to be made during Read-while-write or Read-on-first-pass-after-write.

6.6 Number of Elongated Gaps

The number of gaps which have been elongated (see 7.11.4) due to erase instructions is a matter of agreement between interchange parties, but it is recommended that this number not exceed 2, or alternatively 1% of the total number of blocks written, whichever figure is larger.

6.7 Alignment Error

When adjusted for maximum output, the azimuth angles for a Reference Alignment Cassette, and the information to be interchanged, shall not differ by more than ±15'.

6.8 Tape Winding Torque

The take-up torque shall be at least 3mN·m (0.43 oz-in). The maximum continuous value of the take-up tape tension shall be constant or decrease with increasing reel diameter and shall not exceed 0.5 N (1.81 oz). The above values apply during winding, re-winding, recording and playback.

6.9 Residuals of Previous Recordings

In the zone of the tape in which the outer edges of the tracks are allowed to vary (see 7.2.2), there can be residuals of previous recordings.

7. Format

7.1 Number of Tracks

There shall be two tracks (see Figure 8).

7.2 Track Dimensions

7.2.1 Track Width --

The track width shall be 1.45mm (0.057 in) nominal.

7.2.2 Distances Between Tape Centerline and Track Edges --

The distance between centerline of the tape and the outer edges of the tracks shall be between 1.830mm (0.072 in) and 1.905mm (0.075 in). The distance between the tape centerline and the inner edges of the tracks shall be between 0.37mm (0.015 in) and 0.51mm (0.020 in).

7.3 Track Designation

7.3.1 With side "A" up, the designation of the two tracks is as follows:

When the tape moves from left to right with the magnetic surface facing the observer, and with the leader of side A to the right, the bottom track is designated track No. 1 and the upper track is designated track No. 2 (see Figure 1).

7.3.2 The recording starts with track No. 1; at its conclusion the cassette may be turned over and the recording can be continued with track No. 2.

7.4 Use of Tracks

The use of track No. 1 is reserved for data interchange. The use of track No. 2 is to be indicated on the label. If it is not used in the same way as track No. 1, reading of track No. 2 requires agreement between sender and recipient of the cassette.

7.5 Location of Characters on the Tracks

Each character is located in a byte (octet) of eight bit-positions along the track numbered from 1 to 8 in order of recording.

7.6 Sequence of Recording

The least significant bit is recorded first. The information to be interchanged is recorded serially by bit and by character.

byte

Bit-positions: ...4321[87654321]8765432...

Forward Tape Motion: ⟶

Resulting Recording Direction: ⟵

7.7 Code

The characters are represented by means of the American National Standard Code for Information Interchange (ASCII X3.4-1968) and amendments thereto.

7.7.1 Recording of 7-bit Coded Characters --

Each 7-bit coded character is recorded in bit-positions 1 to 7 of a byte; bit-position 8 is recorded with value ZERO. The relationship is as foliows·

Bits of the 7-bit combination·	0	b_7	b_6	b_5	b_4	b_3	b_2	b_1
Bit-position in the byte:	8	7	6	5	4	3	2	1

7.7.2 Recording of 8-Bit Coded Characters --

Bits of the 8-bit combinatiqn	a_8	a_7	a_6	a_5	a_4	a_3	a_2	a_1
Bit-position in the byte·	8	7	6	5	4	3	2	1

7.8 Sequence of Characters

The sequence of characters from start toward finish of a block is corresponding to the normal left to right sequence of a written line.

7.9 Data Block

A data block shall consist of a preamble, data and postamble. The data portion of a data block including the CRC (see 7.13) shall contain a minimum of 32 bits and a maximum of 2064 bits.

7.10 Control Block

A control block (known as tape mark) shall consist of a preamble, two bytes of eight ZERO bits each, and a postamble.

7.11 Gaps

7.11.1 Integrity of gaps --

The gaps shall be DC erased. Immediately before and after each block there shall be a length of at least 2.5mm (0.10 in) in which, exclusive of the residual edge signals, there is no flux discontinuity capable of producing a read signal of more than 10% of one-half of the Standard Reference Amplitude. In the remaining part of the gap there shall be no more than seven (7) flux transitions.

7.11.2 Interblock gaps --

The interblock gap defined as the distance between two successive blocks shall have a nominal length of 20.3mm (0.8 in), shall have a minimum length of 17.8mm (0.70 in) and a maximum length of 250 mm (9.8 in). Any gap in excess of 400mm (15.5 in) shall be considered end of data on this track.

7.11.3 Initial gap --

The gap between the BOT marker and the first block shall be 33mm (1.3 in) minimum and 250mm (9.8 in) maximum.

7.11.4 Elongated gap --

The interblock gap is an elongated gap if its length is between 50mm and 250mm (1.97 in and 9.8 in).

7.11.5 Trailer gap --

The gap following the last block shall have a minimum length of 17.8mm (0.70 in). At least 17.8mm (0.70 in) of this gap shall lie within the tested area (see 4.2.5).

7.12 Preamble and Postamble

7.12.1 Preamble --

Immediately preceding data in each block, the preamble "10101010" shall be written. When reading in the forward direction, the first bit flux transition shall be a ZERO transition.

7.12.2 Postamble --

Immediately following data in each block, the postamble "10101010" shall be written. When reading in the forward direction, the first bit flux transition shall be a ZERO transition.

7.13 Cyclic Redundancy Check (CRC)

The last two characters in the data portion of a data block shall be Cyclic Redundancy Check (CRC). The 16-bit CRC shall be written in each data block following the data and immediately preceding the postamble. The polynomial generating the CRC is expressed as:

$$x^{16} + x^{15} + x^2 + 1$$

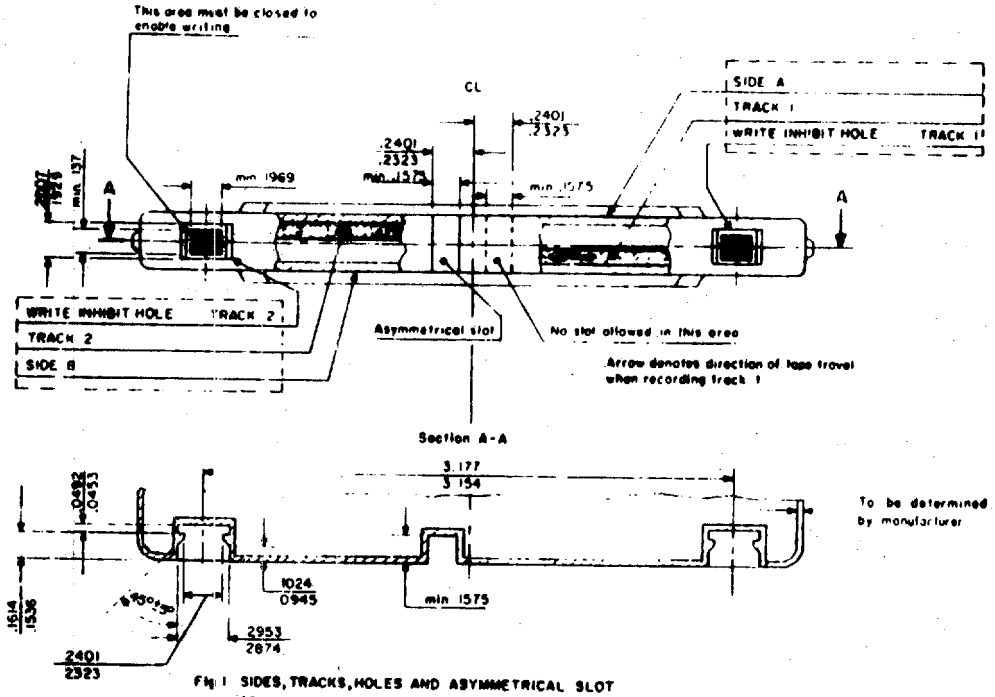


Fig 1 SIDES, TRACKS, HOLES AND ASYMMETRICAL SLOT
(Dimensions in inches)

10 MAY 73

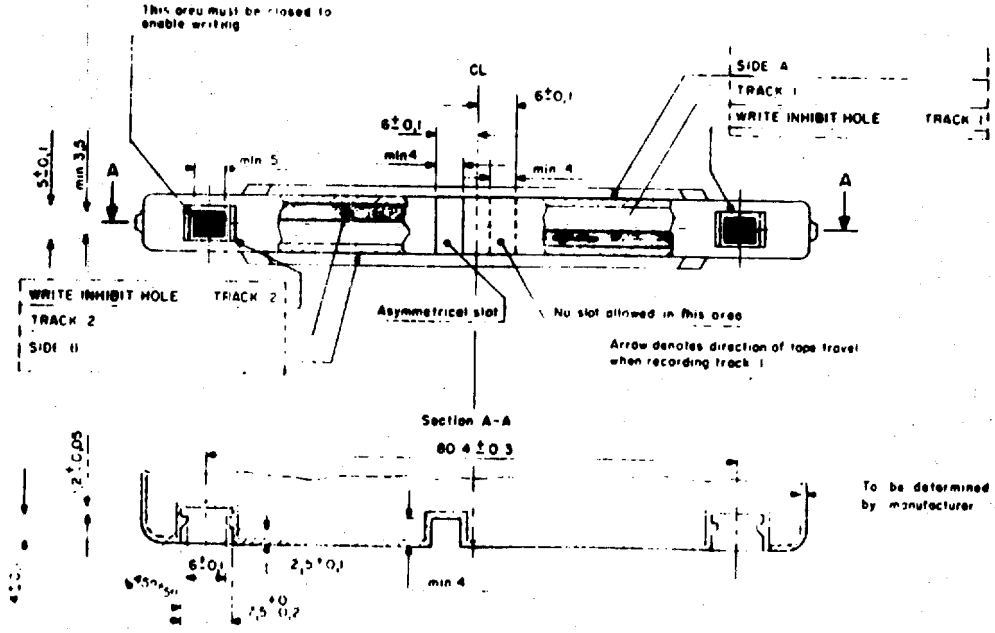


Fig 1 SIDES, TRACKS, HOLES AND ASYMMETRICAL SLOT
(Dimensions in mm)

10 MAY 73

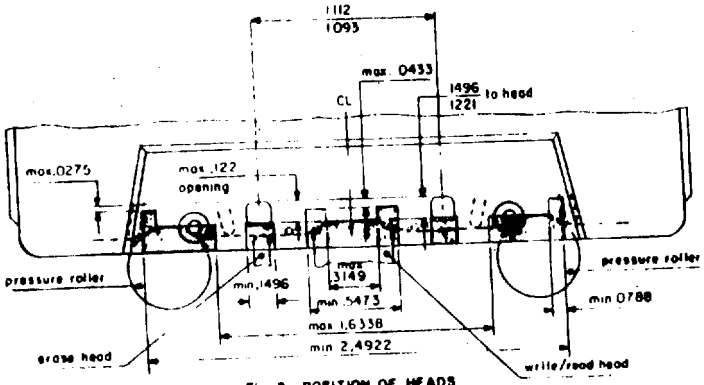


Fig 2 POSITION OF HEADS
(Dimensions in inches)

Shaded areas in figure 2 define openings over the full height of the cassette aperture, unobstructed by fixed members, except for areas covered by the mag tape and pressure pad

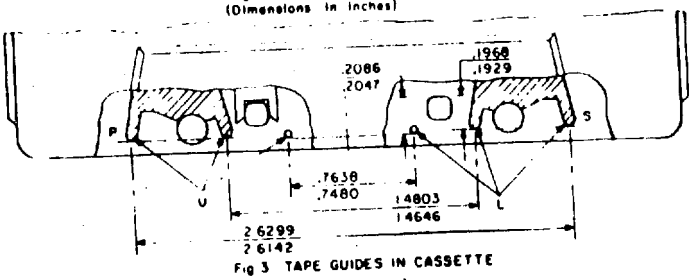
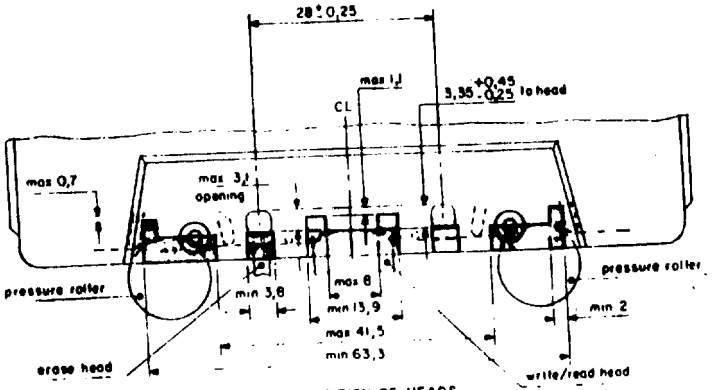


Fig 3 TAPE GUIDES IN CASSETTE
(Dimensions in inches)

10 MAY 73



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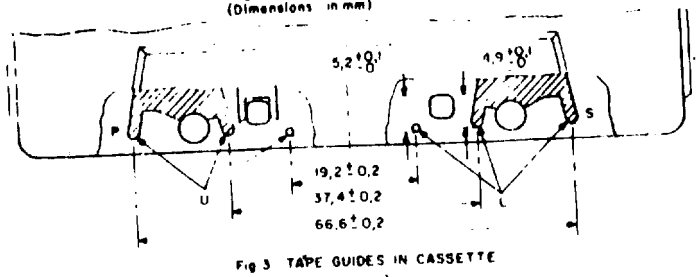


Fig 3 TAPE GUIDES IN CASSETTE
(Dimensions in mm)

10 MAY 73

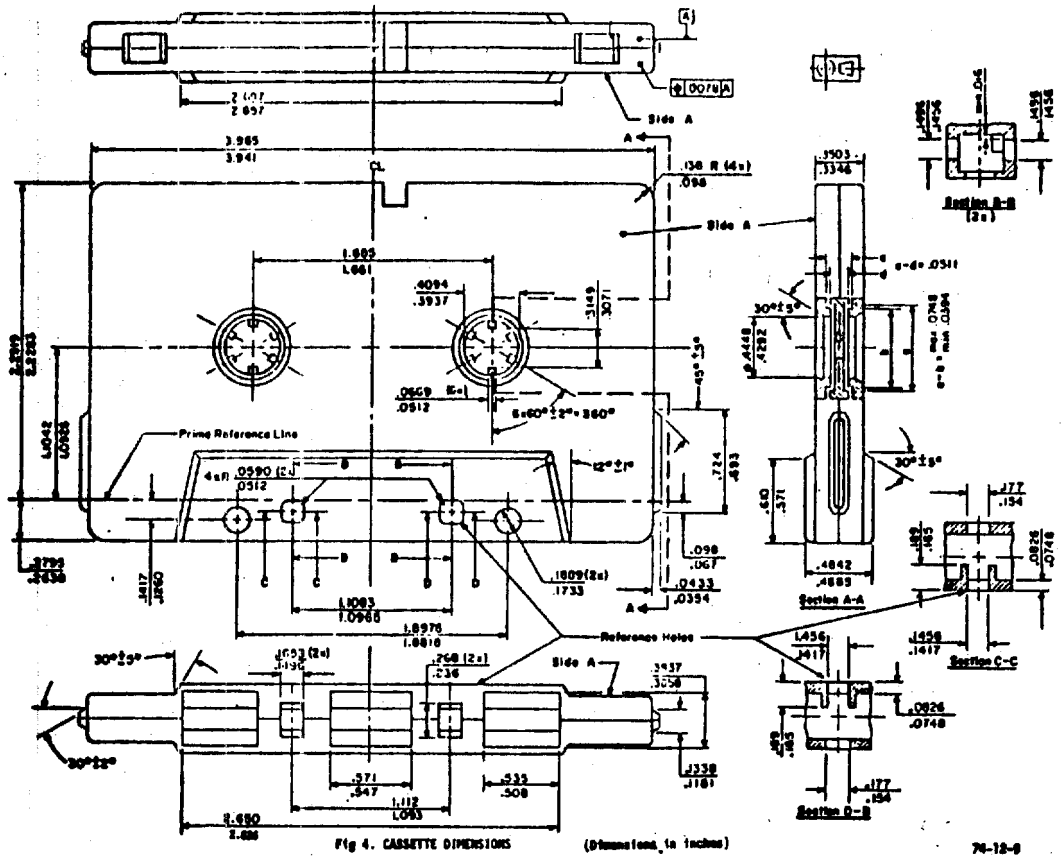


Fig 4. CASSETTE DIMENSIONS (Dimensions in inches)

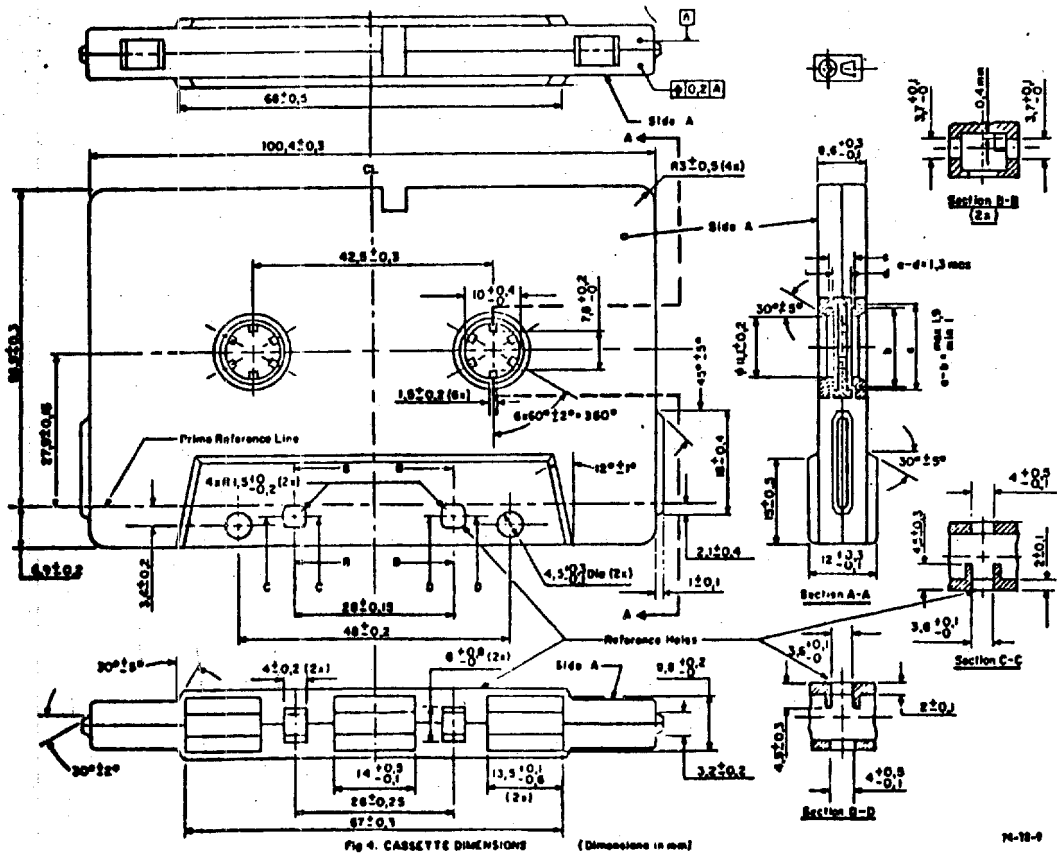


Fig 4. CASSETTE DIMENSIONS (Dimensions in mm)

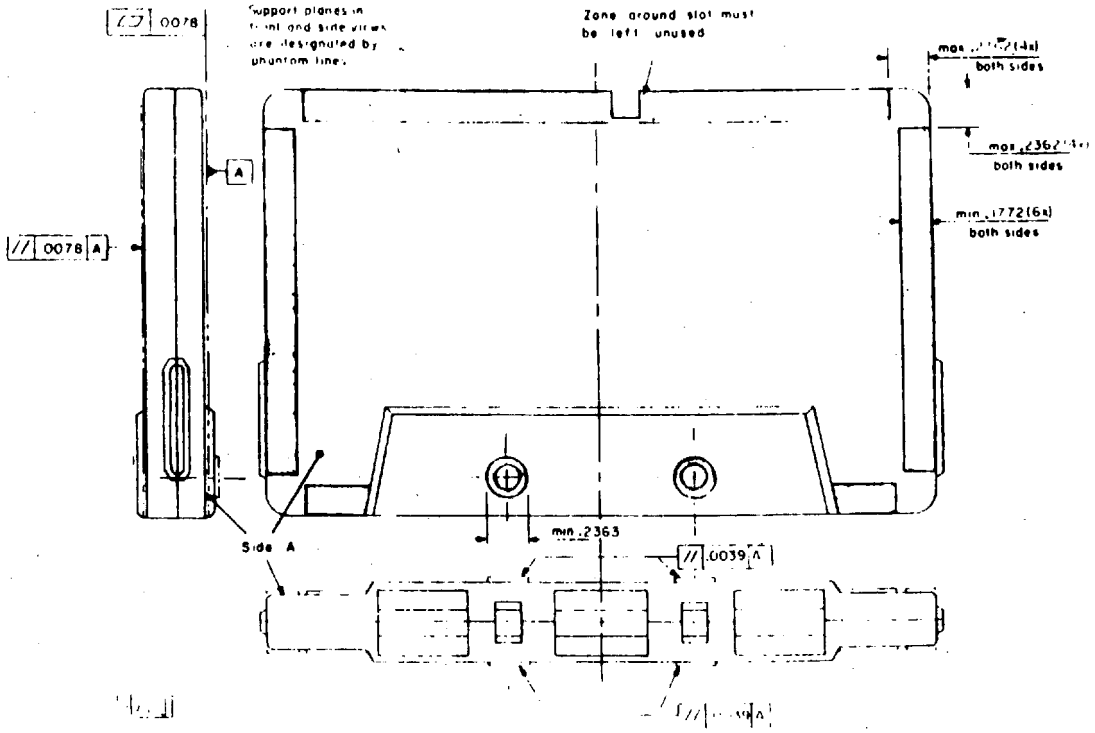


Fig 5 CASSETTE SUPPORT PLANES
(Dimensions in inches)

10 MAY 73

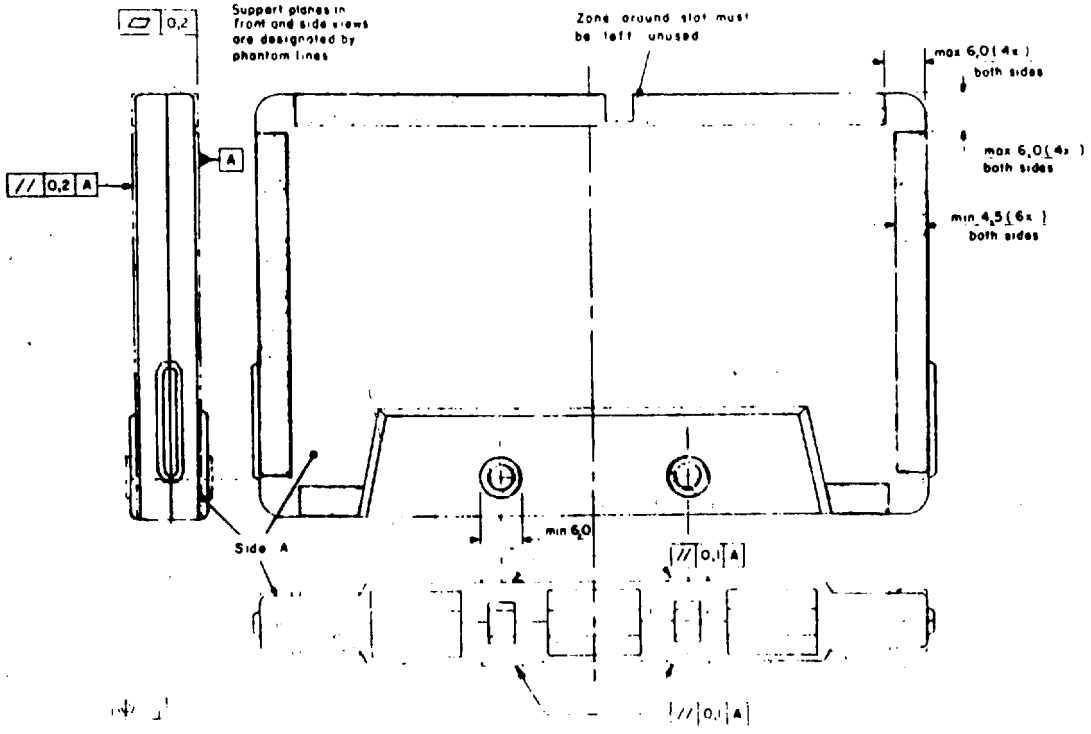


Fig 5 CASSETTE SUPPORT PLANES
(Dimensions in mm)

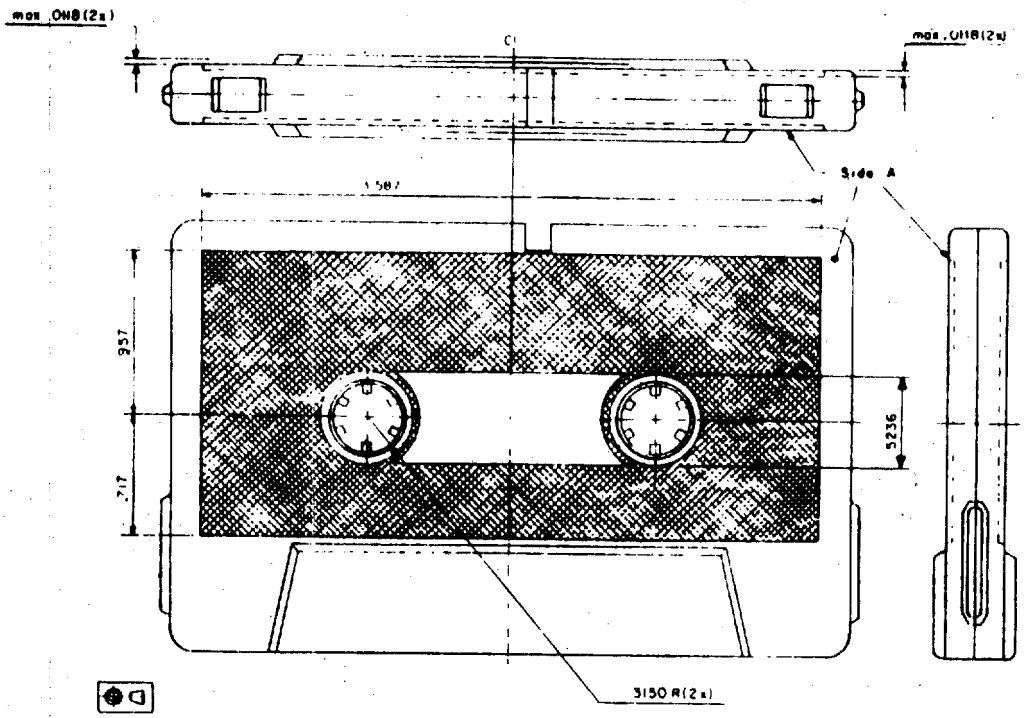


Fig. 6 MAX. LABEL AND WINDOW AREAS DIMENSIONS
(Dimensions in inches)

10 MAY 73

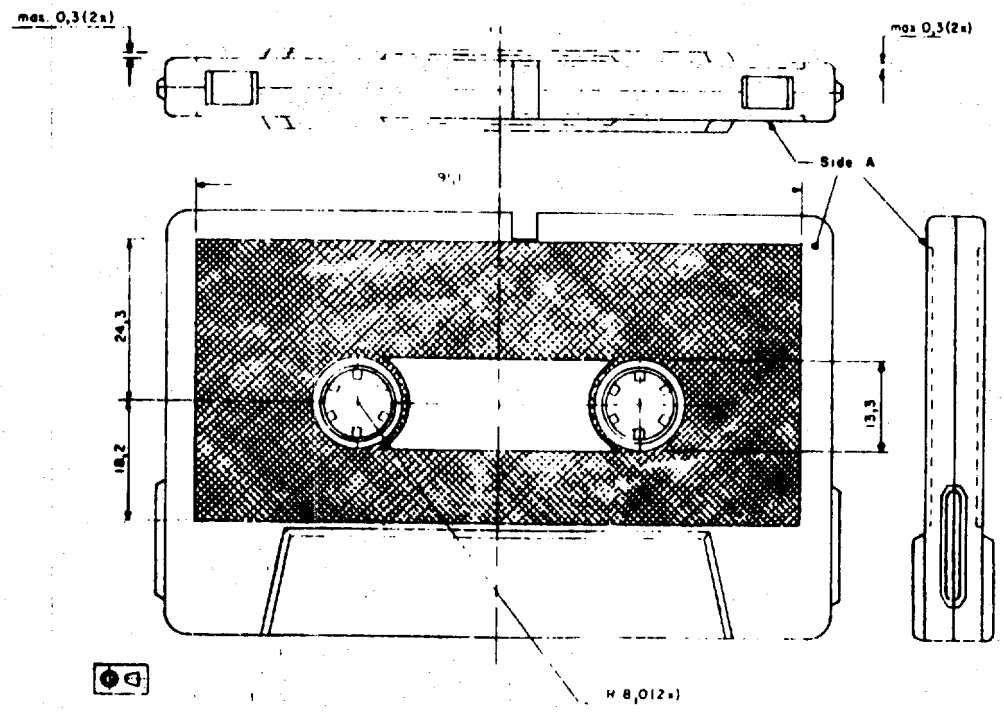
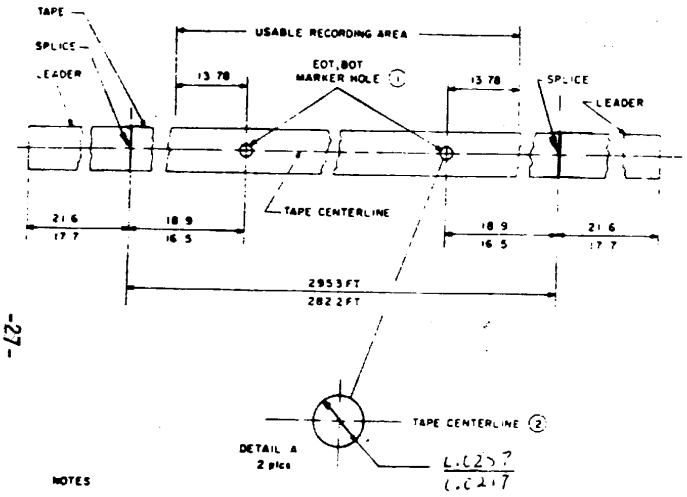


Fig. 6 MAX. LABEL AND WINDOW AREAS DIMENSIONS
(Dimensions in mm)

10 MAY 73



NOTES

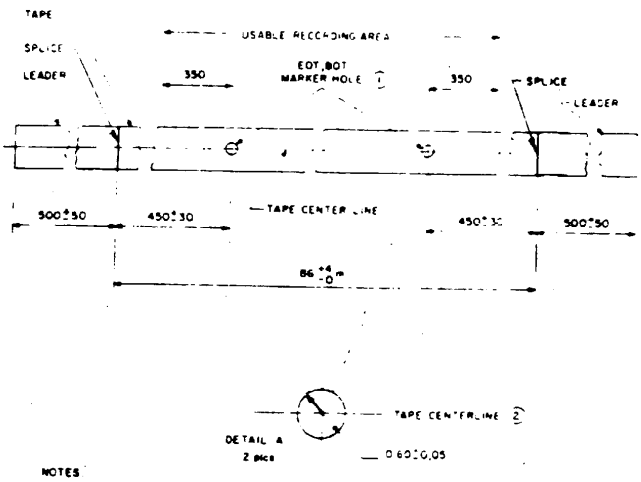
(1) Marker to be hole as shown in Detail A
BOT Beginning of Tape Marker
EOT End of Tape Marker

(2) Distance between Tape centerline and Marker centerline shall be less than 0.0039

3 Dimensions in inches unless otherwise indicated

Fig 7 USABLE RECORDING AREA
(Dimensions in Inches and Feet)

28 AUGUST 73
14 Nov 74



NOTES

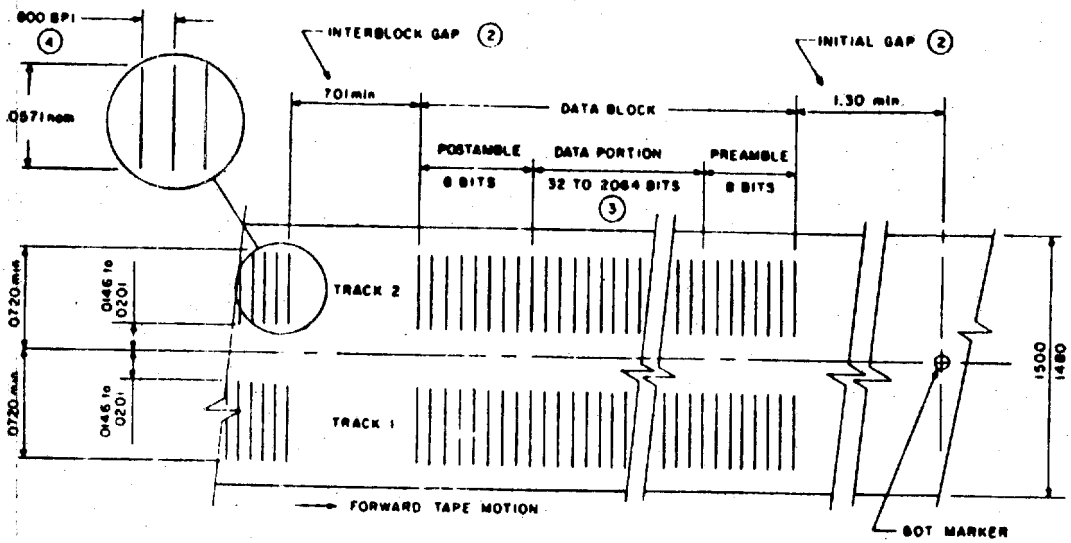
(1) Marker to be hole as shown in Detail A
BOT Beginning of Tape Marker
EOT End of Tape Marker

(2) Distance between Tape centerline and Marker centerline shall be less than 0.1

3 Dimensions in mm unless otherwise indicated

Fig 7 USABLE RECORDING AREA
(Dimensions in mm and m)

28 AUGUST 73
14 Nov 74



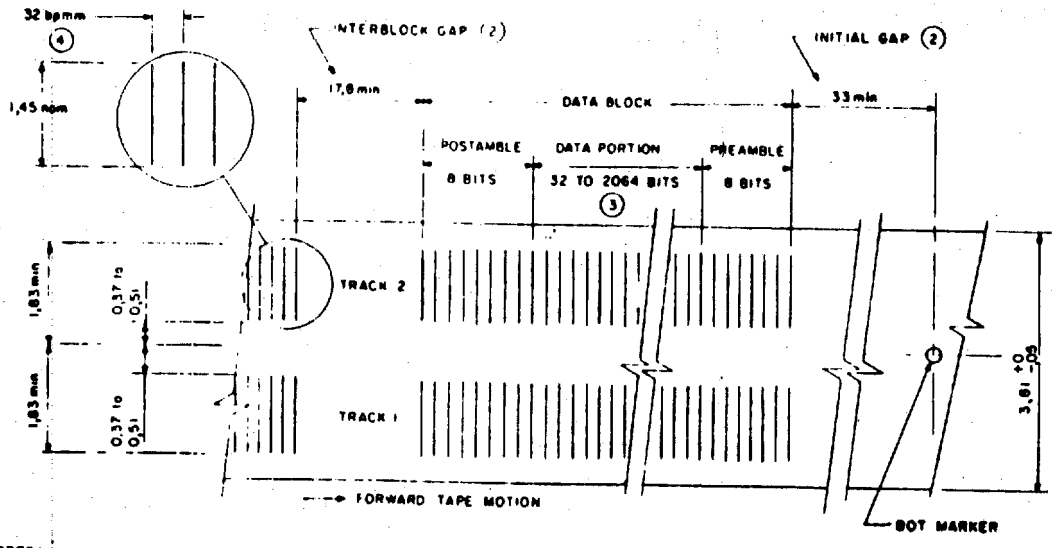
NOTES

1. Tape is shown with oxide side out
2. Tape is fully saturated in the erase direction in the interblock gap and the initial gap
3. The last 2 characters (16 bits) of the data portion are the Cyclic Redundancy Check (CRC)
4. Shown without phase flux reversals that may exist between data bits

Fig 8. RECORDING FORMAT 800 BPI

(Dimensions in inches)

29 AUGUST 73



NOTES:

1. Tape is shown with oxide side out
2. Tape is fully saturated in the erase direction in the interblock gap and the initial gap
3. The last 2 characters (16 bits) of the data portion are the Cyclic Redundancy Check (CRC)
4. Shown without phase flux reversals that may exist between data bits

Fig 9 RECORDING FORMAT 32 bpmm

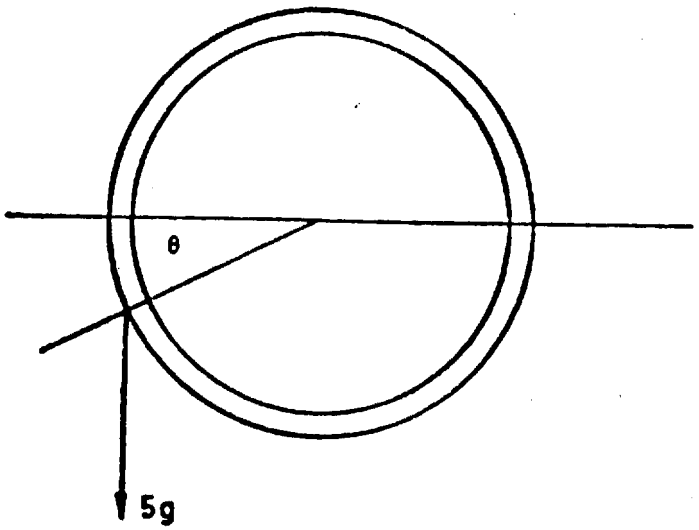
(Dimensions in mm)

29 AUGUST 73

APPENDIX A

Layer-to-Layer Adhesion

A piece of the tape to be tested, about 1 m (39 in) in length, shall be wound around a glass pipe, 36 mm in diameter, with a tension of 3N, (0.67 lb), and fixed at the end. This shall be stored for 24 hours at a temperature of 45 ± 3°C, (113°F ±5°F and at 80% R.H. After this period it shall be stored for another 24 hours in the testing environment specified in Section 3. The tape shall then be unwound with a weight of 5 grams at the end of tape as shown below, and the angle (θ) shall be smaller than 45°.



APPENDIX B

Measurement of Light Transmittance

B.1 Introduction

The description in the following paragraphs outlines the general principle of a test device and the test method to be employed when measuring the radiation (light) transmittance of magnetic tape, including leader.

For the purpose of this document "light transmittance" is defined by convention as the relationship between the reading obtained from the test device with the tape sample inserted and the reading obtained when no sample is present. The transmittance value is expressed as the percentage ratio of the two readings.

The essential elements of the test device are:

the radiation (light) source
the optical path
the measuring mask
the photo cell
the measuring equipment

B.2 Description of the Test Device

B.2.1 Radiation (light) source

A tungsten lamp is used as the radiation (light) source and should be operated in an under-run state.

The colour temperature should be 2000° K ± 200°K and a resulting illumination at the surface of the tape sample of about 5000 lux is recommended.

B.2.2 Optical path

The radiation should be perpendicular to the tape sample and be of substantially uniform intensity. Typically the tape sample should be separated from the lamp by a distance of 150 mm.

A diaphragm of the form shown in Figure B1 is recommended in order to sensibly ensure that scattered radiation does not enter the mask area.

B.2.3 Measuring mask geometry

The measuring mask shall be constructed in one piece according to the drawing shown in Figure B2. A good matt black finish capable of absorbing infra-red radiation is necessary.

Special care must be taken to ensure that the tape sample to be measured is maintained flat in contact with the inner face of the mask.

B.2.4 Photocell

A flat silicon photocell should be used. Its dimensions must be such that the active area of the photocell exceeds the diameter of the mask orifice. It should be mounted parallel and in close proximity to the outer face of the mask.

B.2.5 Measuring Equipment

The measuring equipment should be connected directly across the photocell to measure the output current. In order to be able to set the measuring equipment to full scale deflection (100%) a shunt potentiometre in the circuit must be provided or a fine adjustment of the lamp power supply voltage is required.

The load impedance across the photocell should be as low as possible and must not exceed 500Ω. The instrument should have a nominal accuracy of ± 0.1%.

B.3 Test Procedure

B.3.1 For the purpose of the test a sample strip of tape not shorter than 250mm is used.

- The measuring equipment is set to full scale reading representing (100%).

- The sample strip is inserted and 45 observations on different points along the sample are recorded.

- The sample strip is then withdrawn and full scale deflection (100%) is re-checked. If the reading lies outside the range of 99% to 101% the equipment is reset to 100% and a new set of 45 observations is recorded.

B.4 Guidance on Construction

B.4.1 Experience has shown that a projector lamp is most suited as the radiation source. When selecting a lamp, care must be taken to avoid a lamp with optical inhomogenities in the glass envelope. Also, if mirrors or lenses are used in the optical path, they must be placed such that no filament image occurs in the proximity of the mask and photocell area. It is necessary to operate the lamp from a stabilized, regulated power supply.

B.4.2 Special attention must be paid to all surfaces parallel to the optical path and in close proximity to the mask and photocell to avoid reflection of light. Similarly, the method of inserting the tape must ensure that no ambient light leaks through any slot arrangement.

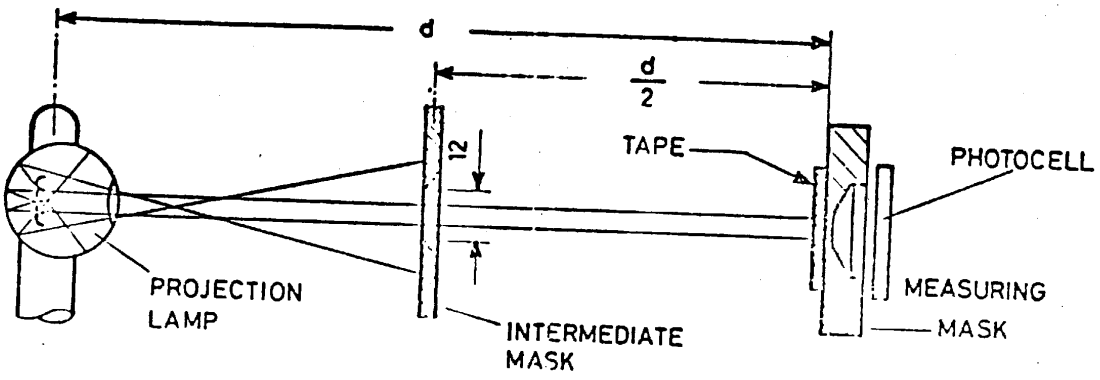
B.4.3 The accuracy of the measurement is dependent not only on attaining the dimensional tolerances shown in Figure 2, but also on the subsequent coating of the surfaces with a high quality optical matt black paint. The mask should be checked after coating to ensure that the small hole remains in tolerance. The method of holding the sample

must be such that the tape is maintained flat in contact with the face of the mask. However, it must allow the sample to be moved without physical damage or distortion.

B.4.4 The photocell must be mounted with care, taking special precaution that the photocell leads do not interfere with the mounting arrangement. It is advisable that the face of the photocell presses slightly on the outer face of the mask.

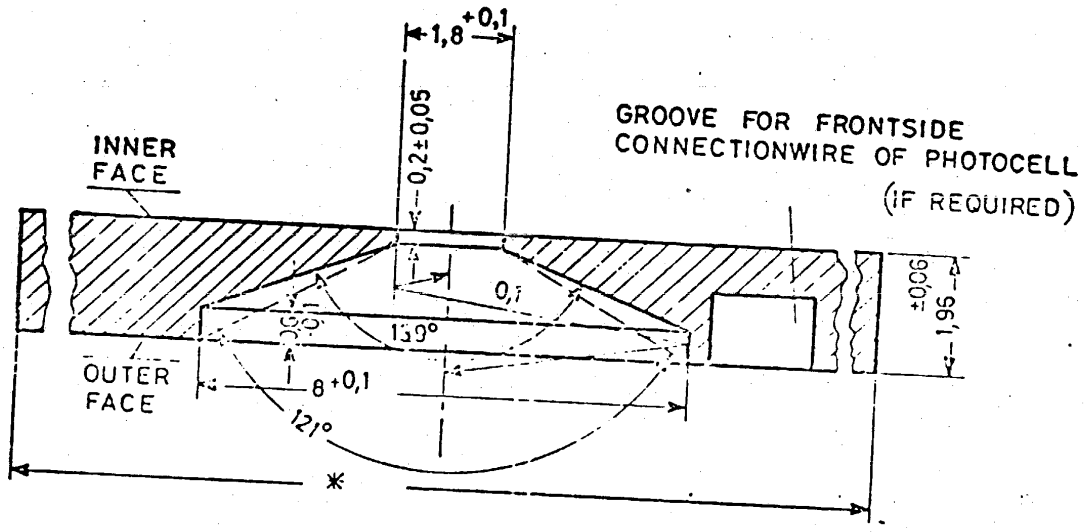
B.4.5 An effective means of providing periodical calibration should be incorporated by inserting an opaque object for 0% light transmittance and a filter glass for 75% light transmittance.

B.4.6 The test device should be cleaned periodically.



d = approx. 150 mm

FIGURE B1 MEASURING DEVICE (DIAGRAM)



* DETERMINED BY USER

FIGURE B2 MEASURING MASK

Expository Remarks Supporting the AN Standard Magnetic Tape Cassette for Information Interchange (Co-Planar 0.150 INCH 800 BPI PE)

CONTENTS

SECTION

R1 INTRODUCTION

In the development of this standard the Philips "Compact Cassette" was taken as the point of departure because of its wide availability and commercial acceptance in audible range recording applications, as well as its embryonic use in digital applications. It offered small size, convenience of operation, relatively low cost and apparent ease of modification to digital application requirements.

Subsequent study has verified this early assumption and has resulted in this standard which while still retaining many of the desirable characteristics of the audible range cassette, defines the mechanical and magnetic characteristics requested for reliable tape and cassette interchangeability in digital applications.

R2 RATIONAL FOR SELECTING CASSETTE AND FORMAT USED

The X3B5 Technical Committee recognizes that the applications for the 150 mil type cassette encompasses the need for a family of standards employing different recording techniques and formats commensurate with applicable system cost and performance. The phase encoded technique as implemented in the proposed standard at a density of 800 BPI is considered to represent the higher performance requirements of the data capturing and data processing applications. The principal reasons for addressing the higher performance requirements first were directly related to:

a. Ensuring that the parallel efforts of the European (ECMA) and ISO standardization activities reflected the identified requirements of the United States cassette and equipment industries and

b. Ensuring that the physical and mechanical properties of the cassette provided an adequate base for the range of performance requirements intended for the 150 mil digital tape cassette.

R3 FUTURE DEVELOPMENT

Recognizing the possibility that other formats and recording techniques will be needed to satisfy the full spectrum of digital cassette applications, X3B5 is presently investigating this area and development of additional standards has been initiated.

R4 TAPE MARK

The DC3 character was chosen originally from the group of Device Control characters provided for such control purposes in the ASCII code set. It was felt that DC3 was appropriate from the code set definition standpoint. The DC3 character choice was also consistent with the precedent established in the 200 and 800 CPI NRZI half-inch magnetic tape standards.

The tape mark configuration consisting of two bytes of 8 zero bits each was first accepted as the European (ECMA) standard Control Block. This configuration was later accepted, with USA concurrence, in the International Standardization Organization (ISO) Standard proposal.

The two byte, all zeros, configuration offers the advantage of being less costly to generate than other arbitrary code selections, without the sacrifice of technical reliability aspects. The two byte Cyclic Redundancy Check (CRC) register is reset to the all zeros configuration prior to the start of the writing of all blocks on tape. The all zeros Tape Mark is generated by simply writing the contents of the reset CRC register onto tape with no further hardware manipulation being required.

R5 PREAMBLE AND POSTAMBLE

In order to recover data with a reasonable degree of reliability, the use of a speed compensation circuit becomes a necessity. The reason for this requirement is evident when the sum of the tolerances is considered. The tolerance to be accounted for includes the ±4% long-term speed variation, the ±5% short-term speed variations and the 10% data bit flux transitions, making a total timing variation of 28%. The theoretical tolerance for data recovery is ±25%. The speed compensation circuit can

compensate for the majority of the 18% speed variations and allow margins for unknowns such as dirt on tape, holes or discontinuities in the tape oxide, noise, etc., and still have reliable data recovery.

X3B5 agreed after lengthy consideration that a two byte long preamble/postamble would provide the best compromise between cost and reliability. The European Computer Manufacturers Association (ECMA) chose to adopt the single byte alternate zero and one pattern. This pattern was later adopted by the International Standardization Organization (ISO) over the objection of the United States.

Discussion within X3B5 subsequent to the adoption of the single byte long configuration within ISO concludes that the two byte (with sentinel) preamble/postamble was still preferred from the data interchange reliability standpoint. However, since no technical data was available to establish the advantage in quantitative terms, a general agreement that the ISO/ECMA configuration would work. In light of a desire to resolve a viable standard in a reasonable time frame consistent with international standards it was agreed to accept the single byte preamble/postamble.

R6 CYCLIC REDUNDANCY CHECK (CRC) CHARACTER

A 16-bit CRC is a better method of performing error detection. An 8-bit CRC was considered but it was not adequate because most of the errors will exceed 8 bits in length. Also, the undetected error rate is unsatisfactory with only 8 bits of redundancy. Therefore, a 16-bit CRC was selected whose generator polynomial is $X^{16} + X^{15} + X^2 + 1$. Even this CRC does not give near the amount of checking that is used on present 9-track, half-inch tapes, which are not subjected to the harsh cassette environment.

The incremental cost to implement the CRC 16 over the cost of the Block Check Character (BCC) is expected to be small. This CRC is also used in communications and hence the likelihood of future availability of a single LSI chip to do this function is increased.

The vastly improved error detection capability of the 16-bit CRC can be seen in the following comparison:

$X^{16} + X^{15} + X^2 + 1$ CRC 16	$X^8 + 1$ BCC
Detects all single errors	Detects all single errors
Detects all double errors*	Can fail to detect double errors
Detects all odd errors	Detects all odd errors
Error Burst of Length 16 Bits or Less	**Error Burst of Length 8 Bits or Less**
0.003% of error bursts of length 17 bits will be undetected	0.78% of error bursts of length 9 bits will be undetected
0.0015% of error burst of length 18 bits or more will be undetected	0.39% of error bursts of length 10 bits or more will be undetected
Detects up to 2 error bursts of length 2 bits or less	Can fail to detect up to 2 error bursts of length 2 bits or less
Can be used to correct some errors*	Cannot be used for error correction

*Maximum code length 32,768 bits or 4096 bytes, including the CRC

Federal Information
Processing Standards Publication

Announcing the Standard for
RECORDED MAGNETIC TAPE FOR INFORMATION INTERCHANGE
(6250 CPI, GROUP CODED RECORDING)

Federal Information Processing Standards Publications are issued by the National Bureau of Standards pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), Executive Order 11717 (38 FR 12315), dated May 11, 1973), and Part 6 of Title 15 CFR (Code of Federal Regulations).

Name of Standard. Recorded Magnetic Tape for Information Interchange (6250 CPI, Group Coded Recording) (FIPS PUB __).

Category of Standard. Hardware Standard, Interchange Codes and Media.

Explanation. This standard specifies the recorded characteristics of 9-track, one-half inch wide magnetic computer tape, including the format for implementing the Federal Standard Code for Information Interchange at the recording density of 6250 characters per inch (CPI). It is one of a series of Federal Standards implementing the Federal Standard Code for Information Interchange (FIPS 1) on magnetic tape media.

Approving Authority. Secretary of Commerce.

Maintenance Agency. Department of Commerce, National Bureau of Standards (Institute for Computer Sciences and Technology).

Cross Index.

a. FIPS PUB 1, Federal Standard Code for Information Interchange.

b. FIPS PUB 3-1, Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI).

c. FIPS PUB 25, Recorded Magnetic Tape for Information Interchange (1600 CPI, Phase Encoded).

d. FIPS PUB 35, Code Extension Techniques in 7 or 8 Bits.

e. American National Standard X3.54-1976, Recorded Magnetic Tape for Information Interchange (6250 CPI, Group Coded Recording).

f. American National Standard X3.40-1976, Unrecorded Magnetic Tape for Information Interchange.

Applicability. This standard is applicable to the acquisition and use to all 9-track magnetic tape recording and reproducing equipments employing one-half inch wide tape at recording densities of 6250 characters per inch (CPI). Federal information processing systems employing such equipment, including associated software, shall provide the capability to accept and generate recorded tapes in compliance with the requirements set forth in this standard.

Specifications. With one exception, this standard adopts the requirements set forth in the American National Standard X3.54-1976, Recorded Magnetic Tape for Information Interchange (6250 CPI, Group Coded Recording), which was developed and approved by the American National Standards Institute. The exception changes paragraph 5.4.3 of X3.54-1976 to read: "Bit Z shall be zero or treated as a bit of higher order than the ASCII bits." This is interpreted as:

. Bit Z shall be a zero when recording the ASCII (FIPS 1) characters
. Bit Z can be other than zero when recording dense numeric, binary, or extended ASCII (FIPS 35) code representations.

Implementation Schedule. All applicable equipment ordered on or after the date of this FIPS PUB must be in conformance with this standard unless a waiver has been obtained in accordance with the procedure described below.

Federal departments and agencies are responsible for issuing specific internal implementation instructions for the use by this standard by their organizational units and for assuring that copies of this FIPS PUB and its associated technical specification (American National Standard X3.54-1976) are made available to all effected parties.

Special Information. For the acquisition of unrecorded magnetic tape, Interim Federal Specification W-T-0051C, Tape, Electronic Data Processing, One-half Inch, Magnetic Oxide-Coated, is applicable. This specification is issued by the Federal Supply Service of the General Services Administration (GSA).

Also, GSA will provide terminology for use of this standard in Federal ADP acquisitions. This terminology will be incorporated in the Federal Property Management Regulations (Title 41, Subtitle C, Part 101, Subpart 101-32.13, Code of Federal Regulations).

Qualifications. None.

Waiver Procedures. (The approval and processing of waivers to Federal Information Processing Standards is currently being reviewed by the Department of Commerce and will be provided in the printed version of this FIPS PUB.)

Where to Obtain Copies of the Specifications.

(To be completed by NBS.)

X3B1/748
4th Rev 75-04-17

X3 Project 233

Draft Proposed

AMERICAN NATIONAL STANDARD

RECORDED MAGNETIC TAPE FOR INFORMATION INTERCHANGE

(6250 CPI, Group Coded Recording)

This draft standard is published for a four-month period of public review and comment. Comments received during this period will be considered and answered. The draft standard, revised as necessary, will then be submitted to American National Standards Committee X3 for letter ballot. Upon completion of the ballot, the proposal will be forwarded to the American National Standards Institute for approval as an American National Standard.

Comments should be returned as soon as possible but not later than 1975 November 19, addressed to:

CBEMA/Secretary X3
1828 "L" St NW
Washington DC 20036

Prepared by

Technical Committee X3B1 - Magnetic Tape

American National Standards Committee
X3 - Computers and Information Processing

Secretariat: Computer and Business Equipment Manufacturers Association

CONTENTS

Approved For Release 2002/05/17 : CIA-RDP83T00573R000600200017-9

CONTENTS

PROPOSED

AMERICAN NATIONAL STANDARD

RECORDED MAGNETIC TAPE FOR INFORMATION INTERCHANGE

(6250 CPI, GROUP CODED RECORDING)

1. SCOPE

This standard is intended to provide a format and recording standard for 1/2-inch, 9-track magnetic tape to be used for information interchange among information processing systems, communication systems, and associated equipment utilizing the USA Standard Code for Information Interchange, X3.4-1968, and amendments thereto. This standard deals solely with recording on magnetic tape and supports and complements American National Standard Unrecorded Magnetic Tape for Information Interchange (9-Track 200 and 800 CPI, NRZI, and 1600 CPI, PE), X3.40-1973, where the following sections are dealt with in detail: general requirements, definitions, tape physical and magnetic requirements, tape reel, and write-enable ring. Compliance with the standard for unrecorded tape is a requirement for information interchange.

CAUTION NOTICE: The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights.

By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the publisher.

No representation or warranty is made or implied that this is the only license that may be required to avoid infringement in the use of this standard.

GROUP CODED RECORDING (GCR): GCR is a recording technique that collects groups of characters and encodes them prior to putting them on tape.

FLUX REVERSAL: The position of a flux reversal is defined as that point which exhibits the maximum free space surface flux density normal to the tape surface.

FLUX SPACING: The space between successive flux transitions is flux spacing.

Block: A group of contiguous recorded characters considered and transported as a unit containing one or more logical records. Blocks are separated by an interblock gap.

INTERBLOCK GAP: A DC-erased section of tape separating blocks of information.

BEGINNING-OF-TAPE (BOT) MARKER: A photo reflective marker placed on the tape for the purpose of indicating the beginning of the permissible recording area.

END-OF-TAPE (EOT) MARKER: A photo reflective marker placed on the tape for the purpose of indicating the ending of the permissible recording area.

DENSITY: The nominal distribution per unit length of recorded information, usually expressed in characters per inch.

SKEW: The deviation of bits within a tape character from the intended or ideal placement which is perpendicular to the reference edge.

TOTAL CHARACTER SKEW: The deviation, during reading, from time coincidence of the bits within a recorded character.

TAPE MARK: A special control block recorded on magnetic tape to serve as a separator between files and file labels.

PREAMBLE: Groups of special signals recorded at the beginning of each block on tape for the purpose of electronic synchronization.

POSTAMBLE: Groups of special signals recorded at the end of a block on tape for the purpose of electronic synchronization.

RECORD CODE: The coded representation of data, padding characters, check characters, and residual characters on tape.

ALTERNATE RECORD CODE: Five bits along any track representing encoded four bits of data, padding characters, check characters and/or residual characters on tape.

DATA GROUP: Is seven data characters plus an ECC character accumulated as a group prior to the record code value translation.

STORAGE GROUP: Is the ten characters created from the data group via the record code value translation.

SUB GROUP: Is one-half of a data or storage group. Control subgroups are separately defined below.

RESIDUAL GROUP: The group that contains the extra characters (the remainder of the number of characters divided by seven); an auxiliary CRC character, and an ECC character. Each such extra character is a residuum character.

CRC DATA GROUP: This group is a specially formatted data group containing one of the CRC characters, the residual character, and an ECC character.

CONTROL SUBGROUPS: Those special subgroups of characters that (except for the subgroup containing the last character) have sets of identical control five serial bit values in the nine tracks.

Mark 1 - A subgroup used to demark data groups from other control subgroups. When media moves in a forward direction, it denotes the onset of data groups.

Mark 2 - A subgroup used to demark data groups from other control subgroups. When media moves in a forward direction it denotes the onset of other control subgroups.

End Mark - A subgroup used to demark the residual data group. When the media is moving in a forward direction, it denotes the next group is the residual group.

Sync Control Subgroup - A subgroup used to indicate recorded frequency and phase to allow synchronization of the VFC.

Terminator Control Subgroup - The first and last subgroup of a record.

Second Control Subgroups - The second and next to last subgroup of a record.

RESIDUAL CHARACTER: This character occupies the seventh group position of the CRC data group and contains two data byte counts, one to modulo 7 and one to modulo 32.

ECC CHARACTER: A special character useable for error detection and correction.

AUTOMATIC READ AMPLIFICATION BURST: A string of bits in all tracks for setting up the amplifiers.

ARA I.D. CHARACTER: A special control block used at the end of the ARA burst to identify the ARA burst when reading backward to load point.

RESYNC BURST: A set of control subgroups identifying format resynchronization points in a block. It is intended that readback circuits can resynchronize operations when sensing such bursts.

CYCLIC REDUNDANCE CHECK (CRC) CHARACTERS: Characters usable for error detection.

AUXILIARY CRC: A CRC character usable for error detection purposes.

LAST CHARACTER: The last character in each block which restores magnetic remanence in all tracks to the DC erase polarity.

3. RECORDING AREA MARKERS

Each reel of tape shall be furnished with two photo-reflective markers, Beginning-of-Tape (BOT) and End-of-Tape (EOT) as shown in Figure 3.

4. RECORDING

4.1 Method

The recording method shall be NRZI (non return to zero, change on one). A "1" bit is represented by reversal of magnetics flux polarity.

4.2 Density of Recording

The density of recording on tape shall be 6250 characters per inch. The nominal maximum flux reversal rate at this density is 9042 FRPI. However the nominal flux reversal rate (1010 pattern) for the following measurements is 4521. The flux reversal spacing at this rate shall be 221.2 microinches subject to these variations:

4.2.1 Long term average (static) flux reversal spacing shall be within $\pm$ 4% of the nominal spacing. This average shall be measured over a minimum of 0.5×10^6 flux reversal intervals.

4.2.2 Short term (dynamic) flux reversal spacing shall be within $\pm$ 6% of the long term average. The short term spacing is the average over two contiguous flux reversal intervals.

4.2.3 The rate of change of the short term flux spacing shall

not exceed 0.26% per flux reversal interval.

4.3 Flux Reversal Spacing

The maximum deviation of flux reversal spacing shall include the effects of Paragraph 4.2.

4.3.1 The average spacing between successive flux transitions at 9042 FRPI shall not differ by more than 2%.

4.3.2 Flux reversal deviations shall be determined by their relationship to specified reference transitions.

4.3.3 The maximum average deviation of flux transitions on either side of the reference flux transitions shall not exceed ± 28% of the average flux reversal spacing at 9042 FRPI.

4.3.4 The average spacing between reference flux transitions on the specified pattern shall not deviate from the computed average by more than ± 6%.

4.3.5 Procedure - The magnetic tape to be used for interchange must meet the conditions of the preceeding paragraphs of Section 4.3 when tested on a reference read chain under the conditions specified in Appendix B.

4.4 Total Character Skew

No data bit in a character shall be displaced more than 664 micro-inches from any other data bit in the same tape character when measured in a direction parallel to the reference edge.

* 4.5 Standard Reference Amplitude

The Standard Reference Amplitude is the average peak-to-peak output signal amplitude derived from the NBS Amplitude Reference Tape (SRM 3200) on a measurement system at the density of 3200 FRPI and the recording current of 1.8 x I_r. The signal amplitude shall be averaged over a minimum of 4000 flux reversals. The Standard Reference Current (I_r) is the minimum current applied to the Amplitude Reference Tape which causes an output signal amplitude equal to 95% of the maximum output signal.

* 4.6 Signal Amplitude

4.6.1 Average Signal Amplitude

The average peak-to-peak signal amplitude of an interchanged tape at 3200 FRPI shall deviate no more than +50%,-35% from the Standard Reference Amplitude. Averaging shall be done over a minimum of 4000 flux reversals, which for the interchange tape may be segmented into groups of 70 flux reversals each.

4.6.2 1600 FRPI Signal Amplitude

The peak-to-peak signal amplitude shall be less than three times the Standard Referance Amplitude.

4.6.3 Minimum Signal Amplitude

An interchanged tape shall contain no adjacent flux reversals whose peak-to-peak signal amplitude is less than 0.2 times the Standard Reference Amplitude.

* 4.7 Erase

4.7.1 Erase direction - The tape shall be magnetized so that the rim end of the tape is a north-seeking pole.

4.7.2 Erase width - The full width of the tape is DC-erased in the direction specified in 4.7.1.

4.7.3 The erase function, whether by the write head or the erase head, shall ensure that the level of the read back signal amplitude is below 4% of the Standard Reference Amplitude at 3200 FRPI.

4.7.4 The erase head shall be capable of erasing other densities (200, 800, 1600) so that the read back signal is below 4% of the Standard Reference Amplitude at 3200 FRPI.

* Most tapes that meet the 3200 f.r.p.i. requirements enumerated in 4.5, 4.6 and 4.7 will interchange when written and read in GCR mode. Further delineation of amplitude requirements with respect to 9042 f.r.p.i. are under consideration by the committee and the National Bureau of Standards and will be included when available.

Interchange parties should be cautioned that the tape subsystem should be compatible in relation to the signal amplitude on the interchange tape.

5. FORMAT

(Figures 1, 2, & 4)

5.1 Track Format - The track format shall consist of nine parallel tracks.

5.2 Track Dimensions

5.2.1 Track width on tape is 0.043 inch minimum.

5.2.2 Center line distance between tracks is 0.055 inch nominal.

5.2.3 Center line of Track 1 to be 0.029 $\pm$ 0.003 inch from the reference edge.

5.3 Reference Edge

The reference edge of the tape shall be the top edge when viewing the oxide coated side of the tape with the rim end of the tape to the observer's right.

5.4 Track Identification

Tracks shall be numbered consecutively, beginning at the reference edge with Track #1, and assigned as follows:

Track	1	2	3	4	5	6	7	8	9
Environment	E3	E1	E5	P	E6	E7	E8	E2	E4
Binary Weight	2^2	2^0	2^4	P	2^5	2^6	2^7	2^1	2^3
ASCII	b_3	b_1	b_5	P	b_6	b_7	z	b_2	b_4

5.4.1 Bits b_1 - b_7 correspond to the bit assignments in ASCII.

5.4.2 Bit P is the parity bit. Character parity is odd in data subgroups, it can be either odd or even on tape.

5.4.3 Bit Z shall be zero and treated as a bit of higher order than ASCII bits.

5.5 Block Length

5.5.1 The data portion of a block shall contain a minimum of 18 ASCII characters.

5.5.2 The data portion of a block shall contain a maximum of 2048 ASCII characters. However, with the agreement of the Interchange parties, larger blocks may be used.

5.6 Preamble

Preceding data in each block, a Preamble shall be written consisting of 80 characters, of which the first and second control subgroups are 10101, 01111 followed by fourteen 11111 control subgroups in all tracks.

5.7 Postamble

Following data, the Residual Group, the CRC Data Group, and the Mark 2, a Postamble shall be written consisting of 80 characters, of which the first 14 subgroups are all "ones" in all tracks followed by 11110 and 1010L in all tracks. (The L character is the last character.)

5.8 Density Identification Area

The GCR recording method shall be identified by a burst of the recording at the BOT marker. This burst shall be in the PE frequence range on Track 6 and erasure on all other tracks. The ID burst shall begin 1.7 inches minimum before the trailing edge of the BOT marker and continue past the trailing edge of the BOT marker.

5.9 ARA Burst

Immediately following the ID burst, there is an ARA burst (all ones in all tracks) and is separated from the ID burst by an undefined gap. This burst of ones shall be placed as follows: It shall begin no sooner than 1.5" nor no later than 4.3" as measured from the leading edge of the BOT marker. It shall end no sooner than 9.5" nor no later than 11.5" as measured from the leading edge of the BOT marker. Appended to the end of the ones burst is an ID character consisting on ones in Tracks 2, 3, 5, 6, 8 and 9 and erasure in Tracks 1, 4, and 7. This ID character shall be approximately two inches long. (At least a contiguous 1/4 inch of this two-inch length must be error free in all tracks at once.) There is a normal IBG between the ARA ID character and the first data block.

5.10 Interblock Gap

5.10.1 Interblock Gap, in addition to Preambles and Postambles:

1. Nominal - 0.3 inch (7,62 mm)
2. Minimum - 0.28 inch (7,11 mm)
3. Maximum - 15 feet (4,6 m)

5.11 Tape Mark

The End of File information is marked by a Tape Mark, a special block written only by the Write Tape Mark command. One or more files may be written on a reel of tape.

The Tape Mark is specified as 250 to 400 flux changes, all "ones", at 9042 FCI in Tracks 2, 5, 8 and 1, 4, and 7, and no recording in Tracks 3, 6, and 9.

5.12 Resync Burst

The Resync Burst consists of a Mark 2, two sync and Mark 1 control subgroups. This burst is interleaved in the block every 158 data groups. As a result, there are 158 data groups bracketed by a Mark 1 and a Mark 2 control subgroup (see Figure 2).

5.12.1 End data at expected resync location. If the number of data characters remaining in the block after the 158th data group is less than seven, there will be an END MARK control subgroup instead of a Resync Burst.

5.13 Storage Group

The ten record characters representing one data group are illustrated in Figure 4. The lowest numbered character position is closest to BOT.

5.14 Mark 1 Control Subgroup

The Mark 1 control subgroup is one set of nine parallel 5-bit serial values, 00111 in the respective tracks.

5.15 Mark 2 Control Subgroup

The Mark 2 Control Subgroup is one set of nine parallel 5-bit serial values, 11100 in the respective tracks.

5.16 END MARK

The END MARK control subgroup is one set of nine parallel 5-bit serial values, 11111 in the respective tracks.

5.17 Sync Control Subgroup

The Sync Control Subgroup is one set of nine parallel 5-bit serial values, 11111 in the respective tracks.

5.18 Terminator Control Subgroup (TERM)

The Terminator Control Subgroup is one set of nine parallel 5-bit serial values of 10101 in the respective tracks located at the BOT end of each block and 1010L at the EOT end of each block where L represents a bit of a last character which restores the magnetic remanence to the erase state.

5.19 Second Control Subgroup

The Second Control Subgroup is one set of nine parallel 5-bit serial values of 01111 in the respective tracks for the BOT end of the block and 11110 for the EOT end of the block interleaved between the respective terminator control subgroups and the sync control subgroups.

5.20 Residual Character

The track assignment for the Residual Character is as follows:

	Mod 32				Mod 7			Mod 32	
Binary Value	2^2	2^0	2^4	P	2^0	2^1	2^2	2^1	2^3
Tracks	1	2	3	4	5	6	7	8	9

Valid Mod 7 binary count are 000 to 110
Valid Mod 32 binary count are 00000 to 11111.
Mod 7 count equals binary value of the remainder of the number of characters in the record divided by seven.
Mod 32 count equals the binary value of the remainder less one of the number of characters in the record divided by thirty-two.

5.21 Data Group

Seven data characters plus an ECC character arranged as follows:

	Subgroup A				Subgroup B			
Group Position	1	2	3	4	5	6	7	8

where Positions 1-7 contain data characters
Position 8 contains the ECC character that is generated as per Paragraph 6.2
(See Figure 4 and Table 1)

5.22 Residual Data Group

Group Position 1-6 Residuum data characters or padding
Group Position 7 Auxiliary CRC character
Group Position 8 ECC character

The residuum data characters occupy the lower numbered positions, with the higher numbered group positions containing padding characters of all 0's with odd parity. The group positions 1-6 may contain all padding or all data characters in accordance with the number of residuum characters Modulo 7.

5.23 CRC Data Group

This specially formatted data group contains the CRC character defined in Paragraph 6.4, and the residual character defined in Paragraph 5.20.

Group Position 1 contains an all-0's character with odd parity or the CRC character, in accordance with Section 6.4.1.
Group Position 2-6 each contains the CRC character
Group Position 7 contains the residual character
Group Position 8 contains the ECC character

6.0 CHECK CHARACTERS

6.1 "Rigorous adherence to Generator Polynomial and computation for each check character is required in the design of check character generating and utilization apparatus or programs."

6.2 ECC Character

The 8th group position of each data group is an 8-bit ECC (Error Correcting Code) character for the possible recovery of errors in such data group (Ref. Fig. 4).

6.2.1 The 8-bits of each data character D_1 through D_7 are coefficients of polynomials D_1 through D_7, respectively, as shown in Figure 4 and having the following track assignments

Polynomial position	X^1	X^4	X^7	-	X^3	X^6	X^0	X^2	X^5
Track number	1	2	3	4	5	6	7	8	9

Track number 4 contains odd parity bit P and is not a part of the ECC character.

6.2.2 The 8-bits of the ECC character E are also coefficients of polynomial E with the same track assignments. Track number 4 contains odd parity on the 8-bit character E.

6.2.3 E is computed from data polynomials D_1 through D_7 using the generator polynomial $G=X^0 + X^3 + X^4 + X^5 + X^8$ according to the following relationship:

$$E = [X^7D_1 + X^6D_2 + X^5D_3 + X^4D_4 + X^3D_5 + X^2D_6 + X^1D_7] \text{ Modulo } G$$

All arithmetic operations are Modulo 2.

6.3 Auxiliary CRC Character

At the end of each block in the residual data group, one 9-bit auxiliary CRC character is inserted into group position 7.

6.3.1 The 9-bits of each character M_1 through M_n, which includes data characters only, are coefficients of polynomials M_1 through M_n, respectively. Characters M_1 through M_n are successive data characters with M_1 being closest to beginning of tape and having the following track assignments:

Polynomial position	X^0	X^4	X^6	X^3	X^1	X^5	X^7	X^2	X^8
Track number	1	2	3	4	5	6	7	8	9

6.3.2 The 9-bits of the auxiliary CRC character N are also coefficients of polynomial N with the same track assignments:

6.3.3 N is computed from data polynomials M_1 through M_n using the generator polynomial $G_2 = X^0 + X^2 + X^6 + X^9$ according to the following relationship: (This polynomial is asymmetrical.)

$$N = [X^n M_1 + X^{n-1} M_2 \text{ ----} X^2 M_{n-1} + X^1 M_n] \text{ Modulo } G_2$$

All arithmetic operations are Modulo 2.

The calculated auxiliary CRC character is modified by the polynomial $1 + X + X^6 + X^7 + X^8$ Exclusive OR'd with N in the corresponding bit position; the resultant is a parity uncorrected auxiliary CRC character.

6.3.4 The auxiliary CRC character has odd parity. If the resultant of 6.3.3 has even parity, parity is changed to odd by inverting the bit corresponding to track 4.

6.4 CRC Character

At the end of each block in the CRC data group, a CRC character is written five or six times (See Section 5.23) for error detection purposes. This character is called the Cyclic Redundancy Check (CRC) character.

6.4.1 The 9-bits of each character M_1 through M_n, which includes all data characters, the padding characters in the residual data group, and the auxiliary CRC character but excludes all ECC characters, are coefficients of polynomials M_1 through M_n, respectively. Characters M_1 through M_n are successive characters with M_1 being closest to beginning of tape and having the following track assignments:

Polynomial position	X^6	X^8	X^4	X^0	X^3	X^2	X^1	X^7	X^5
Track number	1	2	3	4	5	6	7	8	9

The CRC character has odd parity. If n is even, then the CRC character is repeated in each character position 1-6 inclusive of the CRC data group. If n is odd, then a padding character of all 0's with odd parity is character M_n and appears in byte position 1 of the CRC data group. The CRC character is repeated in each character position 2-6, inclusive.

6.4.2 The 9-bits of the CRC character C are also coefficients of polynomial C with the same track assignments.

6.4.3 C is computed from data polynomials M_1 through M_n using the generator polynomial $G_1 = X^0 + X^3 + X^4 + X^5 + X^6 + X^9$ according to the following relationship:

$$C = [X^n M_1 + X^{n-1} M_2 + \ldots\ldots\ldots X^2 M_{n-1} + X^1 M_n] \text{ Modulo } G_1$$

All arithmetic operations are Modulo 2.

6.4.4 The calculated CRC character is modified by the polynomial

$$1 + X + X^2 + X^4 + X^6 + X^7 + X^8$$

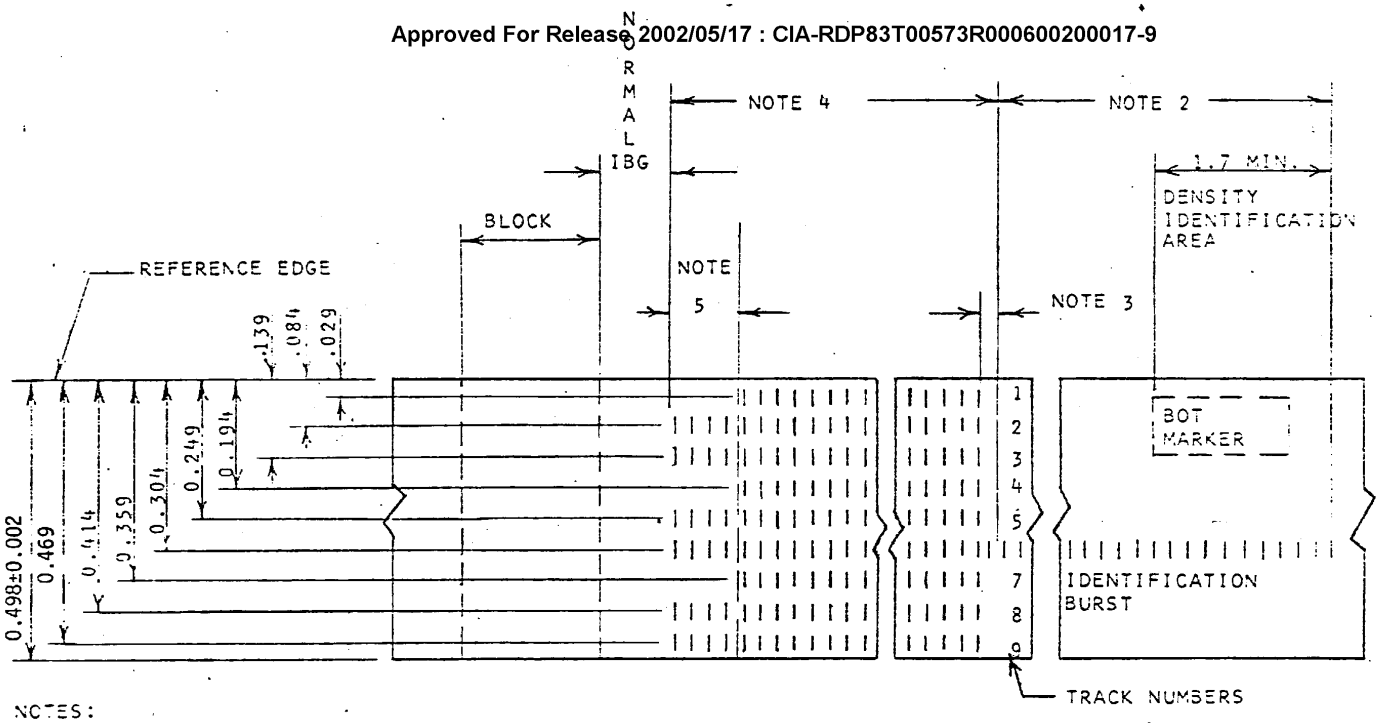
Exclusive OR'd with C in the corresponding bit positions; the resultant is the CRC character.

6.4.5 This check character is identical to the check character defined in Section 5.9, USA Standard on Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI), 1973, Number X3.22-1973.

7.0 REVISION OF AMERICAN NATIONAL STANDARD REFERRED TO IN THIS DOCUMENT

When the following American National Standard referred to in this document is superseded by a revision approved by the American National Standards Institute, Inc., the revision shall apply:

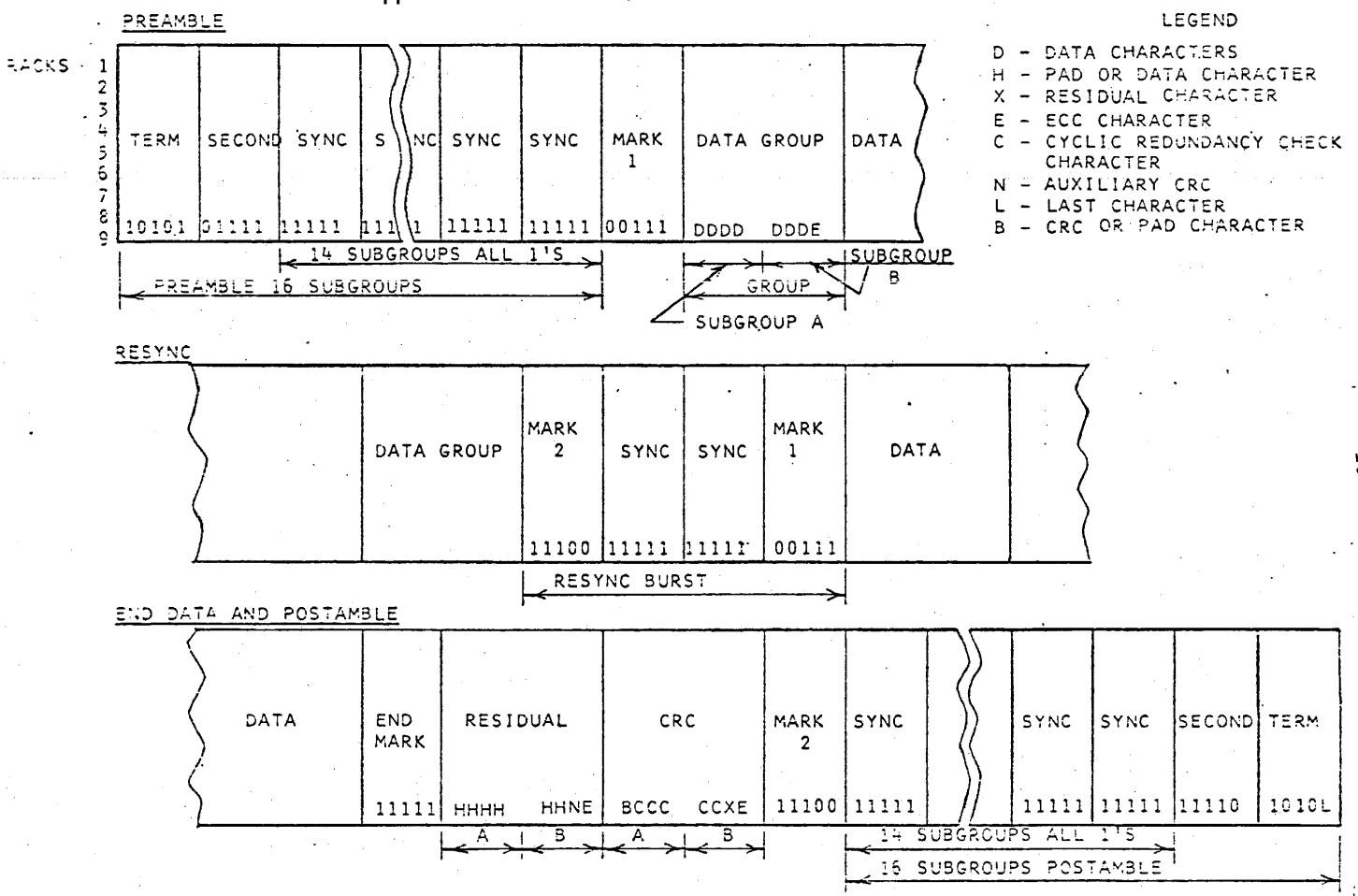
American National Standard Code for Information Interchange, X3.4-1968



NOTES:

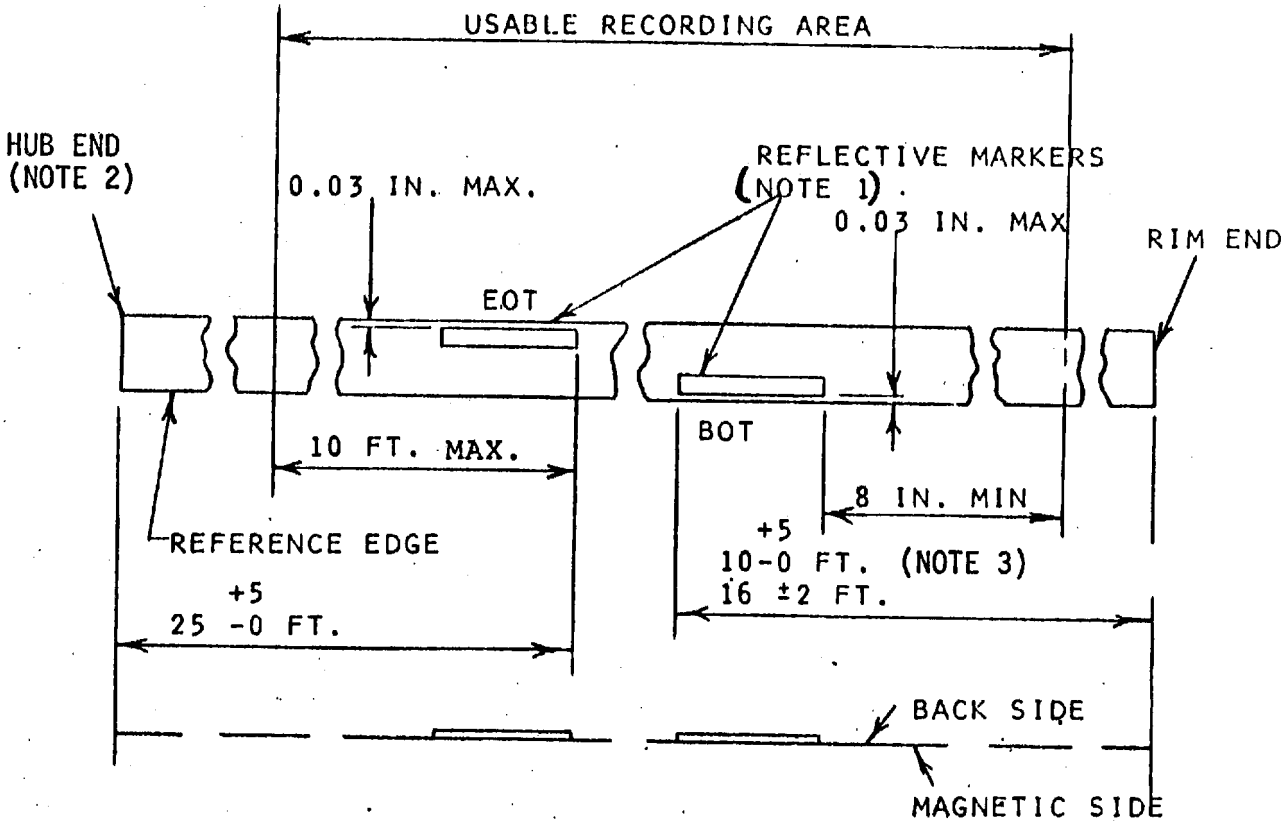
1. TAPE IS SHOWN IN 6250 MODE, OXIDE SIDE UP.
2. I D BURST- SEE PARAGRAPH 5.8.
3. UNDEFINED GAP- SEE PARAGRAPH 5.9.
4. ARA BURST- SEE PARAGRAPH 5.9.
5. ARA I D CHARACTERS- SEE PARAGRAPH 5.9.
6. TAPE TO BE FULLY SATURATED IN THE ERASE DIRECTION IN THE INTERBLOCK GAP AND THE I.D. AREA.
7. ALL DIMENSIONS GIVEN IN INCHES.
8. THERE IS A TRACK PLACEMENT TOLERANCE OF ±0.003 FOR EACH TRACK.

FIGURE 1 RECORDING FORMAT (6250 CPI)



NOTE: THIS FIGURE PORTRAYS THE FORMAT PRIOR TO THE ENCODING OF THE DATA, RESIDUAL AND CRC GROUPS AS PER TABLE 1. THE CONTROL SUBGROUPS ARE RECORDED ON TAPE AS SHOWN AND DESCRIBED.

FIGURE #2 FORMAT

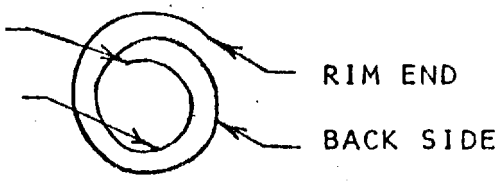


NOTES:

1. PHOTO REFLECTIVE MARKERS SHALL NOT PROTRUDE BEYOND THE EDGE OF THE TAPE AND SHALL BE FREE OF WRINKLES AND EXCESSIVE ADHESIVE.

   MARKER DIMENSIONS:

   LENGTH 1.1 IN.±0.2 IN.
   WIDTH 0.19 IN.±0.02 IN.
   THICKNESS
   0.0008 IN. MAXIMUM



FRONT VIEW OF TAPE WIND

2. TAPE SHALL NOT BE ATTACHED TO THE HUB.

3. TWO VALUES FOR PLACEMENT OF THE BOT MARKER ARE GIVEN, BOTH OF WHICH CAN BE HANDLED BY MOST TAPE UNITS. THE 16±2 FT. IS THE NEW ANSI STANDARD.

FIGURE 3. USABLE RECORDING AREA

EXAMPLE
DATA GROUP TO STORAGE GROUP

		DATA GROUP		STORAGE GROUP	
		Data Sub-Group "A"	Data Sub-Group "B"	Storage Sub-Group "A"	Storage Sub-Group "B"
Physical Tracks	1	DDDD	DDDE	XXXXX	XXXXX
	2	DDDD	DDDE	XXXXX	XXXXX
	3	DDDD	DDDE	XXXXX	XXXXX
	4	PPPP	PPPP	XXXXX	XXXXX
	5	DDDD	DDDE	XXXXX	XXXXX
	6	DDDD	DDDE	XXXXX	XXXXX
	7	DDDD	DDDE	XXXXX	XXXXX
	8	DDDD	DDDE	XXXXX	XXXXX
	9	DDDD	DDDE	XXXXX	XXXXX
Group Positions		1234	5678	12345	678910

Tape is recorded in 9-bit characters (across tape) by 10 bits long. This 90-bit group is called a "Storage Group". Prior to the record code values conversion, there are eight linear bits which are made up of seven data bits and one check bit. This group of 72 bits is called a "Data Group". The 4-bit and 5-bit combinations are called "Sub-groups".

FIGURE 4. Example: Data Group to Storage Group

RECORD CODE VALUES

Group Positons	Data Values 1234/5678	Record Values 12345/678910
	0000	11001
	0001	11011
	0010	10010
	0011	10011
	0100	11101
	0101	10101
	0110	10110
	0111	10111
	1000	11010
	1001	01001
	1010	01010
	1011	01011
	1100	11110
	1101	01101
	1110	01110
	1111	01111

TABLE 1

APPENDIX A

A1. Introduction

A1.1 This recorded magnetic tape standard is intended to implement the American National Standard Code for Information Interchange (ASCII), X3.4-1968, on magnetic tape for interchange among information processing systems, communications systems, and associated equipment.

A1.2 A related standard has been prepared to specify unrecorded magnetic tape. The scope of the unrecorded magnetic tape standard covers the specification and testing of physical and magnetic properties and also the operation and storage environments, identification, control devices, and attachments.

A related standard has been prepared to specify a standard format for blocks recorded on 1/2-inch, 9-track magnetic tape. The scope of the magnetic tape label standard covers the definition, content, functions, and interrelationships of blocks.

A2. Specification Support

A2.1 Tape

A2.1.1 The dimensions in the recorded tape standard are for reference and to facilitate the design and layout of the recording format.

A2.1.2 Additional signal level specifications are detailed in the unrecorded tape standard.

A2.1.3 The 1/2-inch tape width was selected due to its widespread and current usage throughout the industry and the large quantity in existence.

A2.1.4 Tape length must be agreed upon by the interchange parties. The maximum length is to be limited by the requirements for reel dimensions, tape thickness, "E" value, and moment of inertia as given in American National Standard Unrecorded Magnetic Tape for Information Interchange, (9-track 200 and 800 CPI, NRZI, and 1600 CPI, PE), X3.40-1973.

A2.1.5 Special leaders and trailers may be attached in order to meet special transport loading and control requirements wherever needed.

A2.1.6 The tape wind convention is specified to insure uniformity among all users.

A2.2 Recording Area Markers

The marker type and size have been provided in the recorded tape standard so that placement of BOT and EOT could be determined and set forth in the standard. The detail of the marker is set forth in the unrecorded tape standard.

A2.3 Recording Method

A2.3.1 NRZI is an accepted method of recording and as implemented herein can be used at the given density.

A2.3.2 DC erase of the full width of the tape is provided to insure that all previously recorded information is removed prior to recording new information.

A2.4 Format

A2.4.1 Number of Tracks. The 9-track format was selected for the following reasons:

(1) The de facto standard (7-track) is not capable of easily handling ASCII; a minimum of 8 tracks is desirable.

(2) The addition of the ninth track permits alternate, noninterchange uses of the same tape and equipment. (See Section A3 of this Appendix.)

A2.4.2 Track Dimensions

A2.4.2.1 The track locations (centerline of recorded data) are dimensioned from the reference edge of the tape. Tracks are numbered 1 through 9 starting at the reference edge. The track location tolerance of $\pm$ 0.003 inch is close enough to prevent undesirably wide deviation in track locations, thus allowing the widest possible read head track width. Wide read head track widths are desirable to provide adequate signal levels and enhance the freedom from defect-caused signal dropouts.

A2.4.2.2 The method of dimensioning allows equipment manufacturers to make distribution of design tolerances between the write head and the tape transport mechanism as desired.

A2.4.2.3 The minimum recorded track width was selected to provide maximum freedom from defect-caused signal dropouts consistent with reasonable head design practices.

A2.4.2.4 Width of read tracks is not specified. It is assumed that equipment manufacturers will select an optimum read track width for their particular equipment.

A2.4.3 Track Identification and Bit Assignment

A2.4.3.1 The track numbering is logically assigned 1 through 9, starting at the reference edge of the tape.

A2.4.3.2 The bit assignments were selected to agree with previous densities with 9-track format.

A2.4.4 Parity

A2.4.4.1 Odd character parity was selected to agree with previous densities with 9-track format.

A2.4.5 Block Length

A2.4.5.1 The minimum block length was selected to agree with the 800 CPI, NRZI 9-track format. There is no technical restriction in the GCR method which necessitates a minimum data length requirement.

A2.4.5.2 Each record containing less than seven data characters shall consist of a preamble, Mark 1, END DATA, control subgroups, a residual and CRC data groups, a Mark 2 control subgroup, and a postamble.

A2.4.5.3 The maximum block length was selected to permit processing on the smallest systems and accommodation by reasonably sized buffers.

A2.4.6 Gap Sizes

Gap sizes are specified to improve thruput. The maximum gap is specified to permit corrective action

when DRS is exercised in an interchange record (successive erase instructions).

A2.4.7 Tape Mark

The Tape Mark was chosen to minimize the possibility of recognizing it as a data block, and vice versa. For noninterchange applications, similar control block combinations are possible, either across the width of tape or by segmenting the longer length of the control block to provide additional combinations.

A2.4.8 Control Subgroups

These subgroups are not translated but are written as indicated on the tape.

A3. Additional Considerations

A3.1 Introduction

"This standard is intended to define the record on the record tape for interchange purposes. Utilization of machine design criteria has been avoided to provide maximum flexibility to interchange parties in program and machine design."

A3.2 Noninterchange Applications

A3.2.1 Increased character transfer rate.

(1) Density: No restrictions on any other recording technique.
(2) Tape Speed: No restriction.
(3) Packing: Two numeric characters may be placed in one tape character, possibly by the use of Track 7 for one of the bits in a numeric character.

A3.3 Information Exchange Flexibility

A3.3.1 The ASCII concept does not prohibit a variety of inherent subsets and supersets. This American National Standard for recorded magnetic tape will accommodate such flexibility.

A3.3.2 Present equipment design and handling capability was given considerable weight in the choice of the particular attributes of this standard.

A3.3.3 Upon agreement between persons interchanging recorded tapes, nothing in this standard should be taken to prohibit the use of longer block lengths than that specified in this standard.

APPENDIX B

B.1 Procedure and Instrumentation for Measuring Flux Reversal Spacing.

B1.1 Procedure -- The equipment used for recording tapes (Tape Transport) at 6250 bits per inch shall record on the magnetic tape to be used for interchange, using the format described below:

1. Worst-Case Test Patterns

Track 9	1	0	0	1	1	1	0	0	1	1
Track 8	1	1	0	0	1	1	1	0	0	1
Track 7	1	0	0	1	1	1	0	0	1	1
Track 6	1	1	0	0	1	1	1	0	0	1
Track 5	1	0	1	0	1	0	1	0	1	0
Track 4	1	1	0	0	1	1	1	0	0	1
Track 3	1	0	0	1	1	1	0	0	1	1
Track 2	1	1	0	0	1	1	1	0	0	1
Track 1	0	1	0	0	1	1	0	1	1	0

Note: Record tape with data patterns as shown the full length of a 2400 foot reel of tape.

B.1.2 The tape shall be written in any start-stop mode of operation compatible with system operation.

B.1.3 The block shall be recorded in the Group Coded Recording Format.

B.1.4 Instrumentation - A block diagram of specified measurement equipment follows:

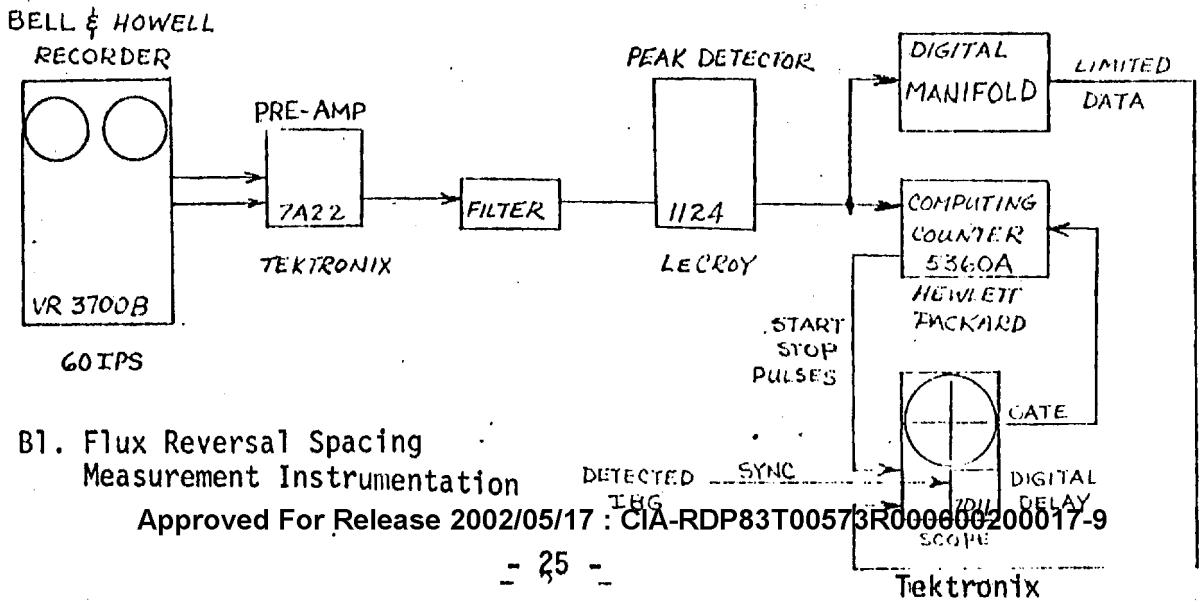


Figure B1. Flux Reversal Spacing Measurement Instrumentation

B.1.5 Reference Transitions

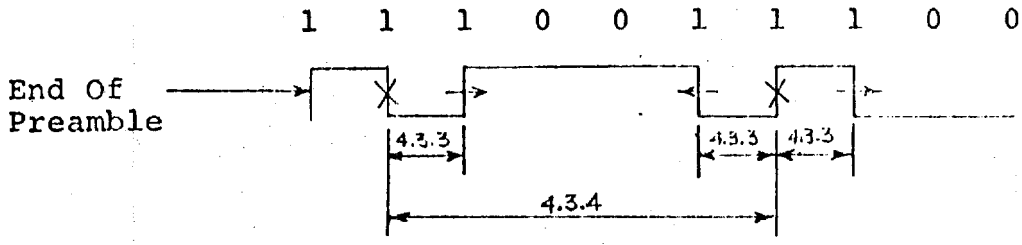


Figure B2. Reference Transitions

B.1.5.1 X - Denotes Reference Transitions

B.1.5.2 Pulse deviations from reference transitions will occur in direction indicated by arrows.

B.1.6 Head

B.1.6.1 There are no voltage output specifications. However sufficient output must be available to minimize signal to noise ratio problems.

B.1.6.2 In the frequency range of 7 KHZ to 400 KHZ the magnitude characteristic shall be within 1 db from a +6 db per octave line.

B.1.7 Explanation

B.1.7.1 Tape from write unit read through instrumentation chain.

B.1.7.2 Digital counter allows delay from detected inter-block gap (IBG) out to transition to be measured.

B.1.7.3 Start-Stop pulses from computing counter displayed adjacent to limited data shows which time between transitions is being measured.

B.1.7.4 Gate from scope to computing counter triggers measurement.

B.1.7.5 Measurement samples are made once on each block for a minimum of 100 blocks.

B.1.7.6 Average measurements associated with Paragraph 4.3.1 are made in the stable part of the preamble closest to the data where the density is 9042 FRPI.

B.1.7.7 Average data pulse width increases are converted

to percentages by comparison with associated positive or negative average flux spacings as measured in B.1.7.6.

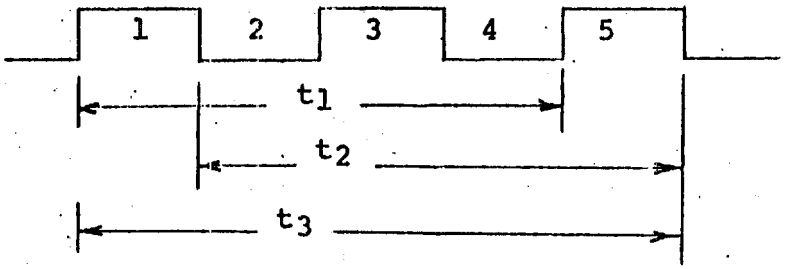
B.1.7.8 Downstream shift of indicated reference transition can be measured directly from a scope display of the pulse train and compared to the predicted computed average flux location.

APPENDIX C

C1 Definition of Rate of Change:

$$\frac{\left| \frac{t_1}{4} - \frac{t_2}{4} \right|}{\frac{t_3}{5}}$$

Where t=time between flux reversals and periods 1 through 5 are contiguous and frequency variations are below 20 khz.



C2 Instrumentation:

C2.1 Any method of measurement which meets the intent of Section C1 is acceptable.

C2.2 Phase components induced in the write process can be a significant part of the measurement. Care must be exercised to minimize the effects of both noise and phase to the point where neither cause erroneous results in the attempt to measure the effect of velocity.

C2.3 Instrumentation utilized.

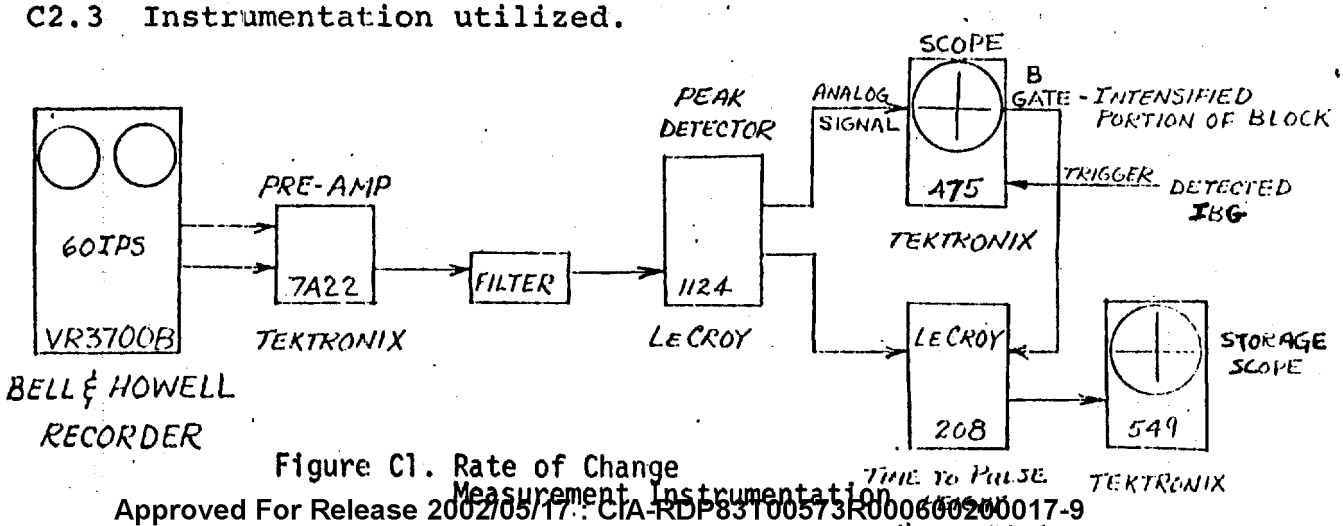


Figure C1. Rate of Change Measurement Instrumentation

C2.4 Explanation:

1. Tape from write unit read through instrumentation chain.
2. Samples made on every other positive pulse of digitized train.
3. Storage scope vertical deflection calibrated in percentage.
4. Time between flux reversals converted to height percentage of nominal.
5. Deviation in percent between pulses read directly and divided by four to test to specification.

Expository Remarks

R 1 Introduction

The following section contains some thoughts and discussions regarding the development of this proposed standard.

R 2 Format

R 2.1 Track Format -- Nine tracks were continued to simplify the conversion to the new density and be backward compatible. These 9-tracks are identical in physical placement and dimensions to prior 9-track interchange standards.

R 2.2 Density/IBG -- The tape subsystem was needed to match the higher performance computing systems. In optimizing the tape subsystem for thruput, data compaction and peak data rate the density and gap delineated in this document were chosen. The upper limit on peak data rate, i.e. density and tape speed, was a match of the channel capability and cable length requirements. With the increased density there was a need for reducing IBG to make efficient use of tape and to maintain the maximum thruput.

R 2.3 Character parity -- The same character parity as used in previous densities was maintained to allow common use of hardware.

R 2.4 Recording Method -- A technique that met the required data rate at the lowest possible tape density was desireable. The lowest tape density was desired to be able to work with existing libraries and still have adequate signal amplitudes. The combination NRZI, E.C.C. and record code values provide the optimized technique to overcome the skew weakness of NRZI.

R 2.5 Detection/Correction -- A method of error correction and detection was desired to provide greater reliability at the high densities. To help accomplish this end objective, a group coded error correction system was employed which provides redundancy for enabling correction of two tracks in error. To minimize undetected, miscorrected errors, a combination of error detection techniques is employed.

R 3 Block Format

R 3.1 Block Length

The block lengths of a minimum of 18 characters and a maximum of 2048 characters is a carry over from previous standards (X 3.39-1973 and X 3.22-1973). This carry over has been continued because of operating system error recovery procedures which are still a common element for all densities.

R 3.2 Inter-Block Gap -- (IBG)

The interblock gap size is selected at any particular density for block sizes and the requirements for improved thruput. As the density increases, it is necessary to reduce the IBG so that efficient use is made of the media.

There is a maximum distance indicated that may be of use depending upon the operating system and hardware design.

R 3.3 Location of ID and ARA Burst

The reading of a tape normally begins at the BOT marker and so it was in this area that the recording method identification burst is defined. This ID burst allows the rest of the tape to be read in the proper mode. This also implies that other tape formats should not have recording in this area. To differentiate between PE and GCR, a different track was chosen for GCR.

The ARA burst format and the length of this burst were implemented to allow usage of the wide variation of tapes that exist. Typically, this area of the tape has more defects than other areas of the tape, therefore, enough length was allowed to insure adequate signals would be available for this function.

The ID character may be recognized as recording in Tracks 3, 6, 9 and 2 or 5 or 8 or as recording in Tracks 2, 5, 8 and 3 or 6 or 9, and the absence of recording is Tracks 1, 4 and 7.

R 3.4 Preamble/Postamble

The preamble and postamble were selected to allow reading either forward or backward as is available via other densities. The actual makeup of the preamble and postamble starts with a lower frequency subgroup that is less affected by media defects and then moves into the high frequency mode for clock synchronization. The actual number of transitions is about the same as that used for the phase encode technique.

R 3.5 Residual Group

As the name implies, it provides a group for the characters that were not direct multiples of seven. Thus, six of the seven available spaces of a data group are potentially data characters. The available seventh position was a convenient place for one of the CRC detection characters.

R 3.6 CRC Group

This group was added to the format to contain another CRC character that was felt necessary to cover any holes that appeared in the various error correction and detection codes because of similarities in the equations. The multiple writing simplified filling up the seven positions is an additional check on the total system detection.

R 3.7 Modulo 32

The modulo 32 count provides a tally of the number of characters in the record and can be used as the designer so desires.

R 3.8 Resync Inverval

This interval is the result of analysis of tape defects where less than a one thousand character record did not seen to require it. For longer records, it was a benefit and did not cost much in efficiency of operation.

R 3.9 Tape Mark

The tape mark was chosen as essentially the same one as the phase encoded one to make system design simplier. The checking is more stringent to equate the reliability to higher density application. A more stringent method, in use, is to recognize the tape mark as recording in Tracks 2, 5, 8, and 1 or 4 or 7, or as recording in Tracks 1, 4, 7, and 2 or 5 or 8 and the absence of recording in 3, 6, and 9.

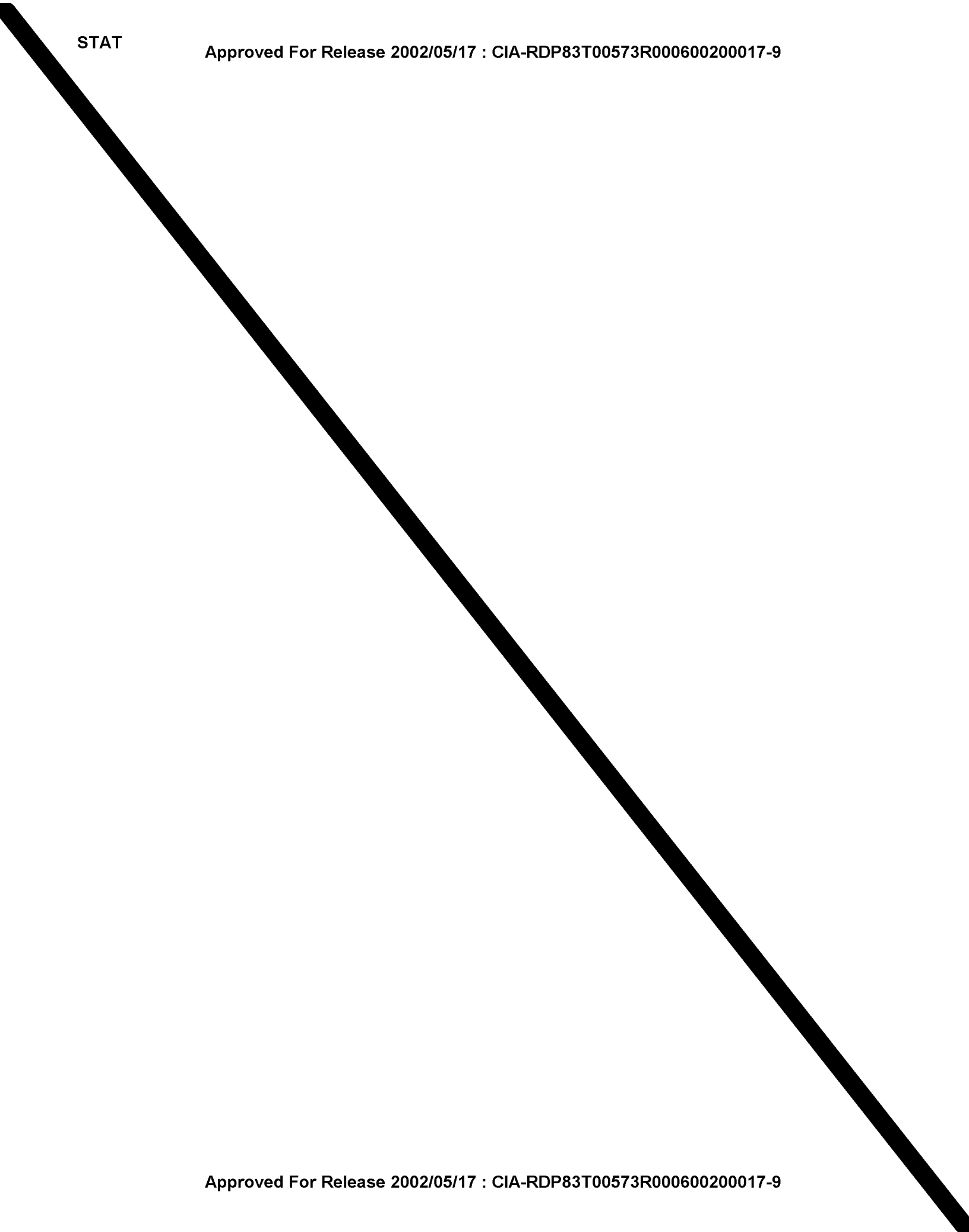
R 3.10 Tape Density

The nominal value of the density on tape was selected so that when the typical overhead was removed, the actual data rate would equal 1.25 meg. bytes per second. This calculation includes the record code value encoding and the resync.

R 3.11 The method of presentation for Section 6 allows freedom of implementation. The notations used in this section are of the type in common usage for describing error detecting and correcting codes.

R 3.12 Auxilliary CRC and CRC Characters

The CRC character is based on a symmetrical polynomial while the auxilliary CRC character is based on an asymmetrical polynomial. This selection enhances error detectability. During read backward, the two characters have to be treated differently.



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